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Children's Learning through Transmedia Materials: A Clustered Randomized Controlled Trial of Two *Pocoyo PlayGrounds*

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Today, it is widely expected that children's media properties will exist simultaneously on multiple platforms (e.g., television, online, apps, toys, games, and puzzles). The term "transmedia" has been coined for this movement of "conveying content and themes to audiences through the well-planned, connected use of multiple media platforms" (United States Department of Education, 2010). Developers and producers of educational media properties for children have begun to leverage this "transmedia" access to themed properties, providing educational materials on multiple platforms and offering a range of learning experiences to children, thereby potentiating their learning. Research studies have indicated that children can learn from educational media such as television (Fisch, 2004) and digital apps (Michael Cohen Group, 2013; Hirsh-Pasek et al., 2015). Studies conducted on multimedia or "transmedia" learning, providing children with access to materials on multiple platforms or a combination of hands-on and media materials, have also shown promising results (Fisch, 2013). However, the extant literature on the impact of "transmedia" materials on children's learning outcomes remains limited. The current study adds to this body of knowledge by empirically evaluating the impact of classroom exposure to a set of themed "transmedia" materials on young children's early literacy skills, in particular, vocabulary acquisition.

Background

In 2010, the Hispanic Information and Telecommunications Network (HITN) was awarded a five-year Ready-to-Learn (RTL) grant by the U.S. Department of Education. The mission of RTL is to promote early learning and school readiness by helping fund the creation of innovative "transmedia" programming for children between the ages of two and eight, with a focus on underserved populations (U.S. Department of Education, 2010). Under RTL, HITN

created the Early Learning Collaborative (ELC) to leverage the power of technology and "transmedia" content to help ensure preschool-age children are fully prepared to begin kindergarten and succeed in school and beyond. To this end, HITN ELC is producing "transmedia" suites of products covering three curriculum areas to support: 1) English language development (ELD) for children whose primary language is Spanish; 2) early literacy; and 3) early math skills in preschool-age children. The suite of HITN ELC products, called *PlayGrounds*, feature the popular children's character, Pocoyo, and his friends. Each *Pocoyo PlayGround* is centered around a preschool-friendly theme (e.g., colors) and includes interactive digital activities (apps) along with hands-on materials. The *PlayGround* concept is premised on an understanding of transmedia materials as providing multiple platforms and experiences for children to explore and learn language and core concepts that are central to preschool curriculum.

As the independent evaluator for this RTL initiative, the Michael Cohen Group (MCG) conducts three kinds of research: formative research to inform the development of the products or properties; secondary research to support the product development process; and, as in the case of the current study, summative evaluations to determine the educational effectiveness of the products. In 2013, MCG evaluated the impact of *Pocoyo* apps ("PlaySets") on the English language development and vocabulary acquisition of ELL children. The present study is focused on the impact of the *Pocoyo PlayGrounds* (theme-based collections of both digital and non-digital products) on young children's early literacy skills.

Objectives

The overall research objective of this study is to evaluate the educational effectiveness of two *Pocoyo PlayGrounds* in supporting early literacy learning and vocabulary acquisition among 3- to 5-year old children. The specific objectives are to investigate the effects of classroom exposure to and play with two *Pocoyo PlayGrounds* themed around colors and community helpers (e.g., police officers, firefighters, teachers) on preschool-age children's: 1) early literacy skills, as measured by the *Get Ready to Read!* (Whitehurst, 2001) screening tool; and 2) acquisition of theme-related vocabulary and concepts, as measured by a customized picture vocabulary recognition task.

This study utilized a randomized controlled trial (RCT) to assess the educational impact of the *Pocoyo PlayGrounds*. The use of an RCT meets the Institute of Educational Statistics' (IES) standards for establishing strong evidence of intervention efficacy. The RCT tests a primary hypothesis that exposure to and interaction with *Pocoyo PlayGrounds* is efficacious in supporting early literacy development and promoting vocabulary acquisition in the topics covered by the *PlayGrounds*. The *Pocoyo PlayGrounds* are a coherent set of themed materials featuring the same characters and story lines. (For a full description of the *Pocoyo PlayGrounds* used in this study, see Appendix A.) The materials against which the *Pocoyo PlayGrounds* were compared (Comparison materials) included similar components (e.g., books, apps, puzzles) that cover the same educational content, but were not created as a themed or unified educational intervention. (For a full description of the Comparison Materials used in this study, see Appendix A.)This study tested whether children in classrooms randomly assigned to the *Pocoyo* Treatment condition achieve greater gains in generalized learning of early literacy skills (as

assessed by a standardized assessment, *Get Ready to Read!)* and learning of program-specific vocabulary (assessed by customized measures) than children in classrooms randomly assigned to the Comparison condition.

The analysis of the findings from this study also includes an examination of whether, through interaction with the *Pocoyo PlayGrounds,* children's early literacy learning and vocabulary and concept acquisition are moderated by their initial level of early literacy skills, familiarity with the *Pocoyo* character, and other demographic variables (e.g., age or gender of child, city, primary language in the home, parent education, etc.).

Methodology

Design

The effects of playing with *Pocoyo PlayGrounds* on early literacy development and learning of vocabulary concepts was tested in a cluster-randomized trial, with randomization stratified by school and age of children in classrooms. Within each of the 10 participating child care centers, classrooms serving 3-, 4- or 5-year-old children were randomly assigned to use either *Pocoyo PlayGrounds* or comparison materials about colors and community helpers. All intervention materials included both interactive digital and non-digital, hands-on educational elements (see details in section below titled Intervention Materials). The intervention was designed to be supplemental to regular classroom activities and instruction. Teachers in participating classrooms were instructed to make the materials available to their students at least three times per week during choice or free play time over a four-week period, with two weeks dedicated to colors and two weeks to community helpers. The order in which the themes were introduced was rotated across classrooms.

The design of the current study includes a comparison of two RTL-funded product suites -- *Pocoyo PlayGrounds* that include apps in conjunction with more traditional hands-on educational materials, all designed to support early literacy development -- with non-RTL-funded, commercially available apps and non-digital, commercially available educational materials that were also designed to support early literacy development in the same curricular areas as the *PlayGrounds*. Classrooms randomly assigned to the Treatment condition used the *Pocoyo PlayGrounds*. Classrooms randomly assigned to the Comparison condition used existing products currently offered in the marketplace (i.e., the Comparison materials).

The inclusion of commercially available materials that address similar curricular content (colors and community helpers) in the Comparison condition was done to meet IES standards and Government Performance Results Act (GPRA) guidelines for summative research studies to "demonstrate positive and statistically significant gains in math or literacy skills when RTL transmedia properties are compared to similar non-RTL-funded digital properties or to other more traditional educational materials" (U.S. Department of Education, 2010).

Criteria for strong evidence. Overall, this study was designed to meet the criteria for "strong evidence" outlined by the U.S. Department of Education, including:

a) Participants centrally randomly assigned to different treatment and comparison conditions;

b) Standardized and documented intervention procedures to enable replication;

c) Use of baseline data to confirm equivalence across conditions prior to the intervention and to statistically control for any differences not removed by randomization;

d) Use of validated assessment measures when possible (assessment of one of the primary outcomes in the present study required a new measure that specifically matched curriculum content);

e) Sufficiently large sample sizes to provide adequate power to detect treatment effects;

f) Research conducted in multiple, geographically diverse sites to maximize external validity;

g) Assertive follow-up procedures to limit attrition to less than 25%;

h) If there is substantial attrition, analyses are conducted on an intent-to-treat basis, using multiple imputation methods to estimate outcomes for subjects lost to follow-up;

i) Reporting of effect sizes and statistical significance;

j) Reporting of positive and negative findings; and

k) Examining process, setting and child factors that moderate or mediate treatment effects to further address external validity.

Analyses of child and setting factors that moderated treatment effects are included in this report. Findings from descriptive data reflecting totals from Teacher Logs and structured classroom observations are also reported.

This multi-site trial was conducted in two geographically diverse locations: New York, NY, and Reading, PA. These two sites provide a contrast between preschools or centers in an underserved urban, densely populated area, and those in a suburban, industrialized, economically challenged, low-income community. Ten early childhood centers or schools serving low-income families were recruited for the study, with 37 classrooms of 3-, 4- or 5-year-old children participating. Classrooms were included if they served a minimum of five students

who had parental permission and were present to participate in the study. Within each school, roughly half the classes were randomly assigned to use two *Pocoyo PlayGrounds*, and half were randomly assigned to a Comparison condition. All participating classrooms were provided with the requisite intervention materials including iPad Minis, chargers, and headphones.

Sample

Participants included a total of 450 children in 37 classrooms across 10 preschool centers who completed the pre-test. Of these, 426 children completed the post-test, for a 95% retention rate. This high retention rate made any bias due to dropout minimal, so only completers were analyzed without having to impute missing data.

Characteristics of participants in the final sample are shown in Table 1. The final sample of 426 included 227 children from 19 classes in the *Pocoyo* Treatment condition and 199 children (from 18 classes) in the Comparison condition. Randomization produced equivalent groups – there were no differences between conditions in child age, child gender, familiarity with *Pocoyo*, or pre-test scores on the *Get Ready to Read!*, Community Helpers measure, or Colors assessment.

Table 1

Characteristics of Participants

	Pocoyo Treatment (n = 227)		Comparison (n = 199)			
	n	%	n	%	Chi square	p
Site					0.00 (1 df)	0.96
New York	117	52%	103	52%		
Pennsylvania	110	48%	96	48%		
Age					2.24 (2 df)	0.33
3	55	24%	38	19%		
4	118	52%	104	52%		
5	54	24%	57	29%		
Gender					0.66 (1 df)	.42
Male	107	47%	86	43%		
Female	120	53%	113	56%		
Race/ethnicity (multiple categories allowed)	(n = 225)		(n =191)			
Hispanic	140	62%	104	54%	2.57 (1 df)	.11
African-American/African	57	38%	46	38%	0.01 (1df)	.93
Asian-American/Asian	24	11%	30	16%	2.32 (1 df)	.12
Caucasian	9	4%	17	9%	3.88 (1 df)	.05
Parent education	(n = 156)		(n = 145)		5.94 (5 df)	.31
Less than high school	1	1%	0	0%		
Some high school	34	22%	35	24%		
High school graduate	45	29%	48	33%		
Some college	45	29%	36	25%		
College graduate	19	12%	22	15%		
Some graduate school	12	8%	4	3%		
Household income	(n = 166)		(n = 142)		1.03 (4 df)	.91
< $20,000	97	58%	84	59%		
$20,000 - $39,999	58	35%	49	35%		
$40,000 - $49,999	7	4%	7	5%		
$50,000 – $79,999	3	2%	2	1%		
$80,000 - $99,9999	1	1%	0	0%		
Home language	(n = 193)		(n = 171)		2.13 (1 df)	.14
Language other than English	139	72%	111	65%		
English	54	28%	60	35%		

Table 1

Characteristics of Participants (continued)

	Pocoyo Treatment (n = 227)		Comparison (n = 199)			
	n	%	n	%	Chi square	p
6 to 12 months	81	43%	60	37%		
13 to 24 months	46	24%	47	29%		
Over 2 years	36	19%	30	18%		
Devices Child Use in the Home	(n = 204)		(n = 197)			
Television	146	72%	121	71%	0.03 (1 df)	.86
Computer	72	35%	71	42%	1.53 (.1 df)	.22
Game console	82	40%	65	38%	0.22 (1 df)	.64
Tablet	132	65%	121	70%	1.16 (2 df)	.28
Smart phone	126	62%	99	59%	0.39 (1 df)	.53
	(n = 227)		(n = 199)			
	Mean	SD	Mean	SD	t (1, 424 df)	P
Familiarity with *Pocoyo* characters (range 0 to 4)	2.34	1.07	2.37	1.06	-0.27	.78
Baseline scores on outcomes						
Get Ready to Read! (range 0 to 25)	13.26	4.85	13.29	4.84	-.06	.95
Community Helpers (range 0 to 29)	10.61	5.50	10.77	5.43	-0.65	.52
Colors (range 0 to 21)	9.02	2.84	9.19	2.47	-0.31	.76

Intervention Materials

All participating classrooms were provided with 4 or 5 iPad Minis (ratio of 1 iPad per 5 children) pre-loaded with the requisite apps and hands-on materials as specified below.

Materials Provided to Treatment Condition Classrooms. The Treatment condition classrooms received two *Pocoyo PlayGrounds* designed to provide an early literacy, transmedia learning experience that included educational, interactive digital and hands-on materials. Each *PlayGround* focused on one of two preschool curriculum areas: colors or community helpers.

The ***Pocoyo* Colors *PlayGround*** introduces young children to colors using a variety of materials to provide different ways of describing and interacting with colors, such as basic and less common colors, light, dark and neon colors, and color mixing. The different components of the Colors *PlayGround* include: an app with five activities, a floor puzzle, a tabletop puzzle, vocabulary cards, match and tell cards, an interactive oversized storybook, a student-sized version of the storybook, an activity journal, and color paddles. All these elements are bilingual (English-Spanish) and incorporate the common theme of colors. The *PlayGround* also contains a classroom guide for teachers and a home guide for parents.

The ***Pocoyo* Community Helpers *PlayGround*** encourages children to explore and use thematic vocabulary related to community helpers, their jobs, vehicles, tools and uniforms. The different components of the Community Helpers *PlayGround* are: an app with four activities, a floor puzzle, a tabletop puzzle, vocabulary cards, match and tell cards, an interactive oversized storybook, a student-sized version of the storybook, an activity journal, a board game, and Venn Diagram circles for sorting and classification of the vocabulary and match and tell cards. These elements incorporate the common theme of community helpers and, like the Colors *PlayGround* materials, are bilingual. The *PlayGround* also contains a classroom guide for teachers and a home guide for parents. (For further details on the *PlayGround* components, please see Appendix B.)

Materials Provided to Comparison Condition Classrooms. Intervention materials for the Comparison classrooms were selected based on their coverage of similar curriculum content as the *PlayGrounds* and providing interactive digital and hands-on experiences. These materials were culled from existing commercially available apps, books, puzzles, and games.

The **Colors Comparison Group materials** included two apps, two books, flashcards, a puzzle, color mixing lenses and neon gel crayons. The **Community Helpers Comparison Group materials** consisted of an app, two books, flashcards, a puzzle, and a listening lotto game. (For further details on the materials provided to the Comparison classrooms, please see Appendix B.)

Assessment Measures

There were two core measures administered at pre- and post-test sessions, and an additional measure of familiarity with the *Pocoyo* property administered only at pre-test.

The *Pocoyo PlayGrounds* are designed as an early literacy educational supplement largely for use in preschool settings. The measures selected to assess impact included: 1) a standardized assessment of early literacy skills (*Get Ready to Read!*); 2) a customized assessment of the specific concepts and vocabulary related to colors and community helpers); and 3) a *Pocoyo* Familiarity test (see Appendix A for copies of the assessments).

The *Get Ready to Read!* (Whitehurst, 2001) screening tool establishes a baseline for children's early literacy skills, measuring print knowledge (understanding of books, printed letters, and words), linguistic awareness (understanding of how words and language work), and emergent writing (a child's first efforts to create and use print in a meaningful way). The test has been evaluated for its reliability, validity, factor structure, relationship with other literacy assessments, and consistency across children from low- and middle-income backgrounds.

There are no standardized assessments appraising young children's knowledge on colors and community helpers. As such, MCG developed measures customized to the colors and community helpers content covered in the *Pocoyo PlayGrounds*. In light of the participants' age

and developmental stage, the measures were conceived as picture recognition tasks, with items requiring pointing, a single word, or short phrase responses (e.g., researcher points to the picture of a firefighter and ask "What does s/he do?"). The assessments were piloted with a small group of preschool-age children, and revisions were made based on the pilot's findings. The Colors measure involved children naming the colors depicted, identifying the two primary colors that make a secondary color, and distinguishing light/dark/neon and shades of colors. For the Community Helpers assessment, children had to name the community helper or vehicle shown, give a brief description of what the community helper does, and select the item that goes along with their job. Children's responses were coded based on a list of guidelines that reflected the content of the intervention materials.

A simple familiarity with the *Pocoyo* property assessment was administered at pre-test in order to determine the impact of familiarity with the property and its characters. Pictures of the *Pocoyo* characters and screen shots from several other children's shows were presented and children were asked to identify the characters in the pictures.

All outcome measures had good internal reliability. Cronbach's alphas for *Get Ready to Read!* were .80 at pre-test and .83 at post-test. Cronbach's alpha for the Community Helpers measure was .84 at both pre-test and post-test. Cronbach's alpha for the Colors assessment was slightly lower but still adequate -- .74 at pre-test and .72 at post-test.

Procedures

All procedures and materials were approved by an independent institutional review board (IRB) (See Appendix A). For children to participate in the study, parents/caregivers had to

return a signed Informed Consent Form. Children were also asked to provide verbal assent at the beginning of pre- and post-testing.

Pre-test. Child participants were tested one-on-one by an MCG-trained researcher at their school. Researchers guided children through the assessment measures, presenting the images, posing the questions aloud, and recording responses on a paper form. The assessment measures were individually paced; most children completed them in about 20 minutes. *Get Ready to Read!* was administered first. The order in which the Colors and Community Helpers assessments were given was alternated across children to minimize order effects. Researchers later transferred the recorded responses from the paper to digital form (using an iPad or laptop to access a private online form). Children's records were only ever identified by an anonymized identification number.

Teacher Training. Separate training sessions were held at each school for the teachers in classrooms randomly assigned to the *Pocoyo* Treatment condition and those teachers randomly assigned to the Comparison condition. The intervention materials were distributed at these sessions. Teachers and their assistant teachers were taken through their respective sets of colors and community helpers materials, including Teacher Logs. They were encouraged to spend additional time after the training to get more familiar with the materials, particularly the apps. Teachers were informed about the total length of the intervention, how much time to devote to each theme, and how often to put out the materials in their classrooms for their students to use. Teachers were provided with a written summary of study guidelines. They were also given a suggested order in which to introduce the various elements of each *PlayGround* or set of Comparison materials over the two-week periods, but teachers were

encouraged to do what worked best for their classrooms. To minimize order effects, teachers were told which curriculum theme (colors or community helpers) to introduce first. This order was rotated across classrooms. (See Appendix A for copies of the teacher materials.)

Intervention Phase. Teachers were asked to wait to use their assigned materials until all the participating children in their classroom had been pre-tested. Once this was completed, teachers were instructed to put out the materials in their classrooms at least three times per week during choice or free play time over a four-week period, with two weeks dedicated to colors and two weeks to community helpers. To assure fidelity of implementation, teachers were also asked to complete Teacher Logs three times a week to indicate which materials children had access to and used, whether direct instruction was used with any of the materials, any shifts in children's play patterns, and any additional comments they wanted to contribute. At the end of the four-week intervention, teachers were asked to rate on a scale from 1 ("did not enjoy") to 4 ("enjoyed a lot"), their students' overall enjoyment playing with the individual materials.

During this intervention phase, researchers visited all the participating classrooms to conduct a structured observation. During their visits, researchers took note of which intervention materials were out in the classroom as well as which ones children were playing with and how. They also answered any questions from the teachers or handled any issues that might have arisen with the materials. Finally, researchers spoke briefly with the teachers to gather their impressions on the process of integration of the materials and their students' responses to them.

Post-test. Researchers returned to the schools for post-testing four weeks after pre-testing. The procedures were identical to that of the pre-test, except that the *Pocoyo* Familiarity assessment was not given.

Participating schools and teachers received an honorarium for their participation. Participating children received stickers at the conclusion of pre-testing and an age-appropriate book at the completion of post-testing.

Data Analysis Plan

Outcomes analyses are based on the 426 students who completed both the pre- and post-test. With 95% of subjects retained, there was negligible potential for bias due to drop-out. This made multiple imputation of missing data unnecessary and, consequently, the observed data for children who completed both assessments were used.

Main effect of intervention condition on outcomes. Preliminary analyses tested whether there was significant clustering by class (i.e., whether children in the same class tended to get similar scores) on each outcome score at post-test. Community Helpers and Colors scores were significantly clustered by class. Effects on these outcomes were conducted using the SPSS 23.0 mixed models procedure. Mixed models account for observations being clustered within groups, and are appropriate for studies where entire classes rather than individuals are randomly assigned to treatment conditions. Mixed models can include predictors for explicit modeling (fixed effects), as well as variables that should be controlled for without developing specific models of their effects (random effects). Preliminary analyses showed that *Get Ready to Read!* scores were not significantly clustered within class, so effects on this outcome were modeled using simple regression.

Separate models were run to test the effect of the intervention condition on three post-test outcomes: *Get Ready to Read!* scores, knowledge about Colors, and knowledge regarding Community Helpers. The main analyses included the effects of condition and pre-test score on the outcome variable.

Moderator analyses. Additional models were run testing whether various factors moderated the effects of the *Pocoyo* apps on each outcome. The potential moderators tested were child age, site (New York vs. Philadelphia), pre-test score on the *Get Ready to Read!* assessment, and pre-test score on other outcome variables. If the effect of an interaction term (e.g., intervention condition x language spoken by primary caregiver) on post-test vocabulary was significant, this would indicate that the latter variable moderated the effects of *Pocoyo PlayGrounds* on outcomes. This would mean that the effects of *Pocoyo* relative to the Comparison apps were stronger among some subgroups of children than among others.

Results

Effects of the Intervention on Standardized Early Literacy Assessment, Vocabulary and Concept Acquisition

Overview of Findings.

Children in both conditions showed modest gains on all measures. However, relative to children in classrooms randomly assigned to the Comparison group, children whose classrooms were randomly assigned to use the *Pocoyo PlayGrounds* did not have significantly greater improvement in *Get Ready to Read!* scores, nor did they have significantly greater improvement in knowledge about Community Helpers. Findings on learning among children in Treatment condition classrooms who used *Pocoyo Colors PlayGround,* relative to children in

Comparison condition classrooms who used the comparison materials, were more complex. The *Pocoyo* Colors *PlayGround* impacts knowledge about certain, but not all, colors. There was no effect on total Colors scores as a whole. Scores for basic or primary colors at pre-test for children in both conditions averaged 85%, a near ceiling effect for these items. The children in the Treatment condition who used the *Pocoyo Colors PlayGrounds* showed statistically significant greater improvement than children in the Comparison condition in two areas – knowledge of uncommon colors (e.g., turquoise, lavender) and knowledge about color shades. These gains were statistically significant, although the effects were modest.

Detailed Findings: *Pocoyo* Colors *PlayGround.*

Children in classes randomly assigned to use the *Pocoyo* Colors *PlayGrounds* as part of the Treatment condition showed no significant overall improvement in color vocabulary when compared with children in classes randomly assigned to use the Comparison group materials. There were significant findings on outcomes that were related to children's prior color knowledge. In addition, sub-analyses of particular types of color vocabulary and concepts revealed significant differences in learning between the Treatment and Comparison groups.

For the sample as a whole, the mean scores on the 21-item customized Colors measure were similar at pre- and post-test (see left side of Figure 1 below). There was no significant main effect of condition on post-test scores when responses on all 21 items were compared between pre- and post-test (see Table 2, Model 1).

The effect on outcomes of exposure to the *Pocoyo* Colors *PlayGround* varied, depending on children's prior knowledge about colors. There was a significant interaction of condition x

pre-test score on the Colors measure (see Table 2, Model 2). To illustrate this effect, children were dichotomized by their pre-test scores on the Colors measure (see right side of Figure 1). Among children with pre-test scores of 10 or higher (at or above the median of the 21 items), those in in the *Pocoyo* Treatment condition improved by an average of 0.9 points, whereas those in the Comparison condition improved by a mean of 0.4 points. This difference by condition was statistically significant (t (1, 31 df) = 2.00, p < .05). Among children with pre-test scores of 9 or lower (below the median), those in the *Pocoyo Treatment* condition improved by an average of 1.4 points, compared to those in the Comparison condition who improved a fraction more, an average of 1.6 points. This difference by condition was not statistically significant (t (1, 30 df) = -1.11, p < .27).

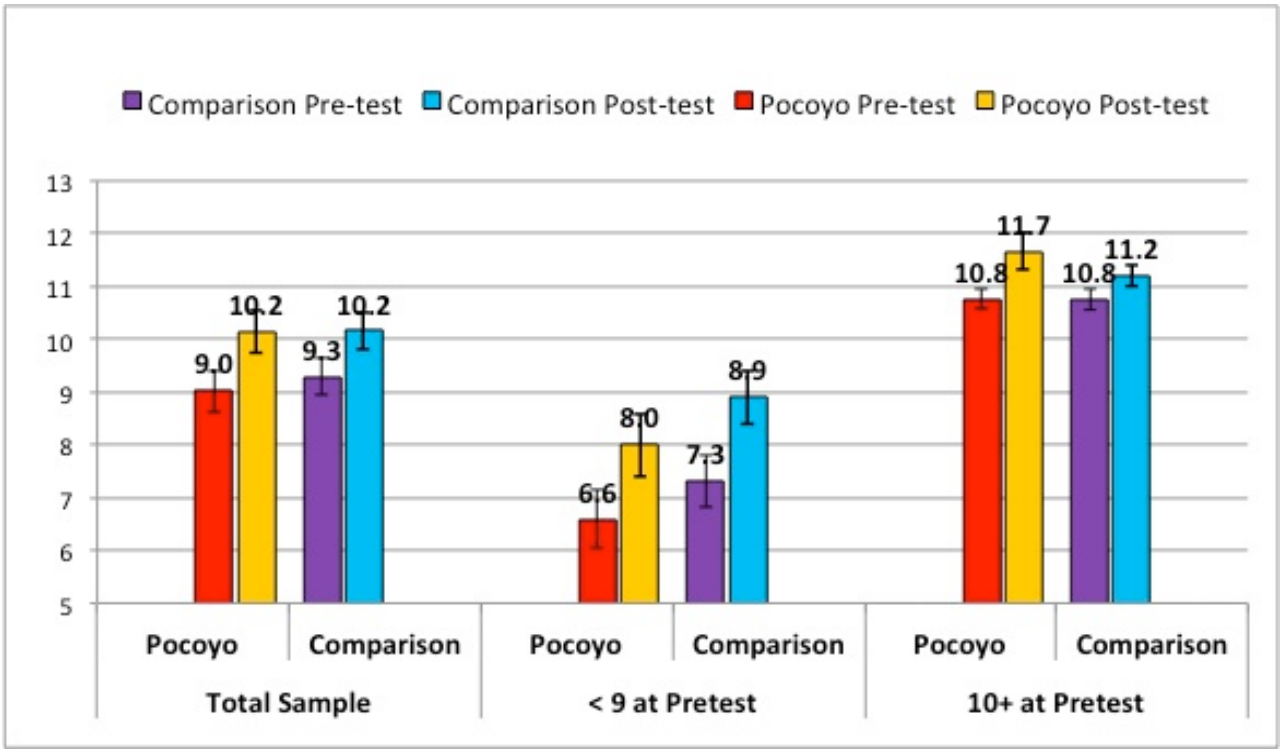

Figure 1. Colors score, by condition and pre-test Colors score

Table 2

Effect of condition and pre-test score on Colors total score at post-test

Model 1 (Main Effects)	b	df	t	p
Pre-test score	.82	1, 420	27.7	.001
Condition	.13	1, 32	0.7	.48
Model 2 (Interaction by pre-test score)	b	df	T	p
Pre-test score	.74	1, 421	15.6	.001
Condition	-1.26	1, 362	-2.2	.03
Condition x pre-test score	.15	1, 421	2.5	.01

Additional moderator analyses showed no difference in the effect of the *Pocoyo* Treatment condition on Color scores by gender or site. There initially appeared to also be potential moderation by age (older children benefited more from *Pocoyo)* and by initial *Get Ready to Read!* scores (higher scoring children benefitted more from exposure to *Pocoyo* Colors *PlayGround* materials), but these effects became non-significant after controlling for pre-test scores on the Colors scale.

Post-hoc analysis – Colors Subscales. The finding that the *Pocoyo* Treatment condition benefitted children with overall better scores on the 21 Colors items at pre-test, but was less helpful to children with lower pre-test Colors scores raised questions about the learning of specific content presented in the *Pocoyo* Colors *PlayGround* materials, as well as the possible interactions between responses to particular items with children's prior knowledge of colors. Post-hoc item analyses were conducted to address these issues.

The *Pocoyo* Colors *PlayGround* materials as well as the Comparison group materials taught several different kinds of content – they taught about common or basic colors (e.g., red, yellow, blue, purple), less common colors (e.g., turquoise, tan), color mixing (e.g., what two

colors make green), and color shades (e.g., light, dark, and neon). We speculated that children who already knew their basic colors might benefit from the more advanced content, whereas children with less knowledge of basic colors at pre-test might be less ready to differentiate and learn uncommon colors and shades. We therefore divided the Colors scale into four subscales based on the different content areas: Basic Colors (10 items), Uncommon Colors (4 items), Color Mixing (3 items), and Shades (4 items). Results are shown graphically in Figure 2 – because the different scales have different numbers of items, we showed the proportion of correct responses rather than raw scores.

In the sample as a whole, knowledge of Basic Colors was relatively high at pre-test (about 85% correct), indicating near ceiling effects on these items. Scores improved a few points between pre- and post-testing in both conditions on Basic Colors, but there was no significant difference in improvement by condition (see Figure 2 and Table 3).

At pre-test, knowledge of Uncommon Colors, Shades, and Color Mixing were all quite low (under 10% correct) for both Treatment and Comparison groups. **At post-test, children in the *Pocoyo* Treatment condition showed significantly greater improvement than did children in the Comparison condition in knowledge of Uncommon Colors** (t 1,422 sd) = 5.2, $p < .001$) **and Shades** (t (1, 31 df) = 6.5, $p < .02$). Children in the *Pocoyo* Treatment condition improved slightly less than children in the comparison condition did on knowledge of Color Mixing but the difference was not statistically significant.

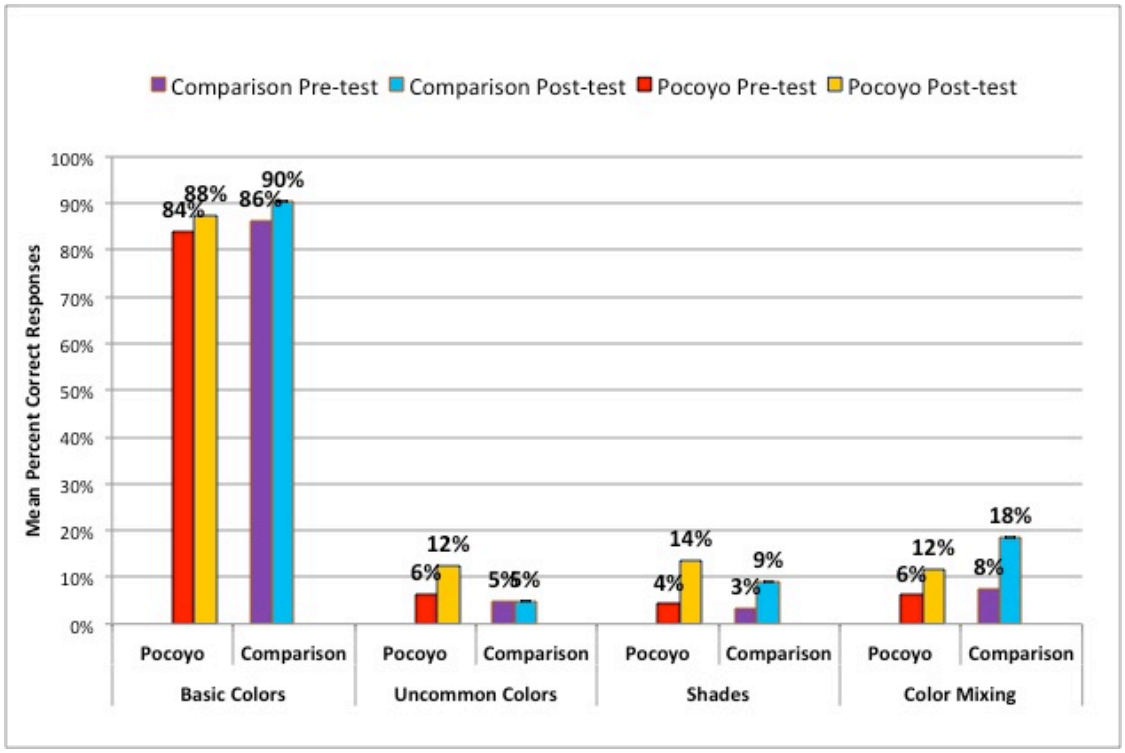

Figure 2. Colors subscale scores, by condition

Statistical models testing the effect of both condition and pre-test knowledge of basic colors on each of these four items (Basic Colors, Uncommon Colors, Color Mixing, and Shades) are shown in Table 3 below. To enable side-by-side comparison, only the b-weights are reported and statistical significance is indicated using asterisks.

Table 3

Effect of condition and pre-test score on Colors total score at post-test

	Basic Colors[a]	Uncommon Colors[a]	Color Mixing[b]	Shades[b]
	B	b	B	b
Pre-test score on outcome	--	.56***	.56**	.44***
Pre-test Basic Colors	.71**	.04***	.05*	.07***
Condition	-.13	.27**	-.16	.19*

[a] Regression model (no significant intra-class correlation).
[b] Mixed model, with clustering of subjects by class. * p < .05, ** p < .01, *** p < .001.

Detailed Findings: *Pocoyo* Community Helpers *PlayGrounds*.

Children in classes randomly assigned to use the *Pocoyo* Community Helpers *PlayGround* Treatment condition showed no significant overall improvement in Community Helpers vocabulary and concepts when compared with children in classes randomly assigned to use the Comparison group materials.

Scores on the Community Helpers measure were similar for children in the *Pocoyo* Treatment and Comparison conditions (see Figure 3). Mixed modeling indicated no significant effect on condition on post-test scores (see Table 4). Additional moderator analyses were all non-significant: the lack of an effect for *Pocoyo* Treatment condition on post-test Community Helpers scores was consistent across all children regardless of their age, gender, prior degree of familiarity with *Pocoyo*, pre-test scores on the *Get Ready to Read!* assessment, or pre-test scores on the Community Helpers measure.

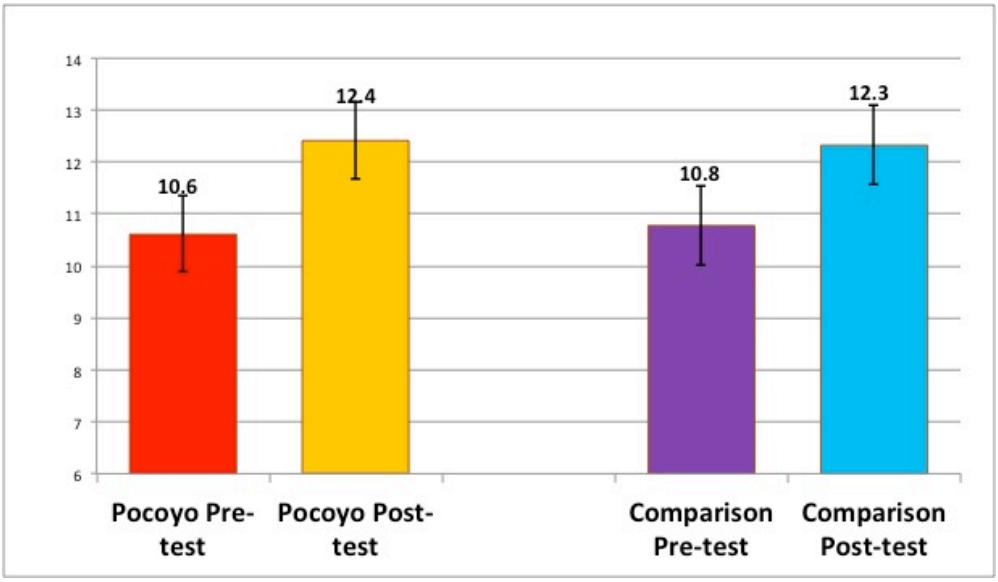

Figure 3. Community Helpers scores by condition, pre- to post-test

Table 4

Effect of condition and pre-test score on Community Helpers total score at post-test

	b	df	T	p
Post-test score	.79	1, 385	26.3	.001
Condition	.28	1, 34	0.7	.48

Post-hoc analysis: Community Helpers Outcomes Related to Language Spoken at Home and Response Formats. There were several trends in the findings that indicated exceptions and particular factors that influenced outcomes on Community Helpers.

First, moderator analyses indicated that there was a significant interaction of condition x language other than English spoken at home (See Table 5, model 2). Relative to the children in the Comparison condition, Community Helpers scores at post-test were marginally better in the *Pocoyo* Treatment condition among children whose families did not speak English at home (See Figure 4). However, within each subgroup (families that speak English at home and families that speak a language other than English at home), differences by condition were not statistically significant.

Table 5

Effect of condition and pre-test score on Community Helpers total score at post-test

Model 1	b	df	t	p
Pre-test score	.79	1, 385	26.3	.001
Pocoyo Treatment Condition (vs. Comparison)	.28	1, 34	0.7	.48
Model 2 (Interaction by Language at Home)	b	df	T	p
Pre-test score	.79	1	24.9	.001
Language other than English at home	1.81	1	3.5	.001
Pocoyo Treatment Condition (vs. Comparison)	.56	1	1.3	.19
Condition x Language other than English at home	-1.43	1	-1.97	.05

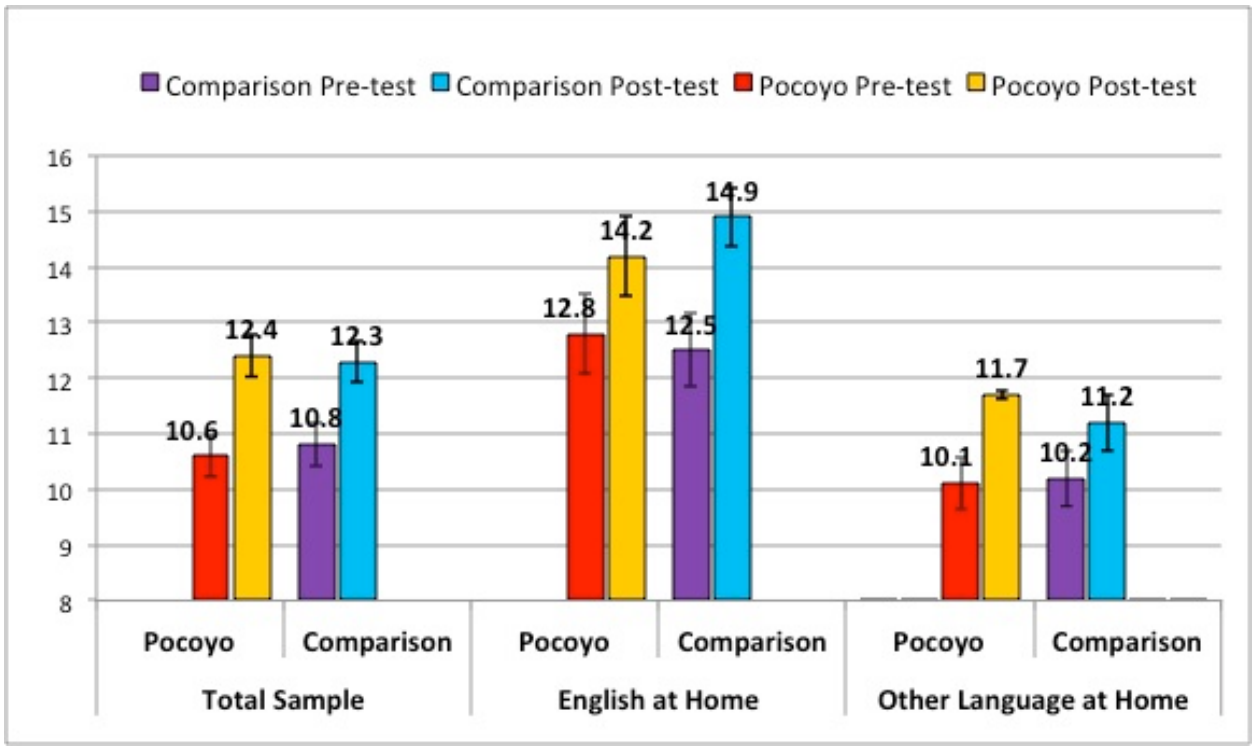

Figure 4. Community Helpers scores, by condition and language spoken at home

Second, during fielding, researchers noted that many children had difficulty responding to Community Helpers "free recall" format questions which required a child to generate a one or two word answer or even a whole phrase or sentence. Children seemed to have less difficulty with "cued recall" questions in which they responded by pointing to one of several pictures. This raised questions about whether the effects of *Pocoyo* Treatment vs. Comparison materials may have been partially obscured by the use of different response formats. To assess this possibility, three Community Helpers subscale scores were computed: one for the five items involving pointing at a correct answer; one for the 19 items requiring a one or two word answer, and one subscale for the five items requiring a sentence or phrase as a response.

These are shown in Figure 5 -- to facilitate comparisons across subscales with different numbers of items, results are presented in terms of the proportion of correct responses.

Children in both conditions generally got higher scores on the Community Helpers items that only required pointing rather than verbal response (see Figure 5). Yet for items with pointing responses, the difference between the *Pocoyo* Treatment and Comparison conditions in how much children improved was very small (d = .07) and not statistically significant (see Table 6). On items requiring a one or two word response, children in the *Pocoyo* Treatment condition improved about two percentage points more than children in the Comparison condition, an effect that approached but did not reach statistical significance (d = .11, p < .10). For items requiring a sentence or phrase response, children in the *Pocoyo* Treatment condition did significantly (d = -.18, p < .05) worse than children in the Comparison condition – scores of children in the *Pocoyo* Treatment condition declined by four percentage points while those of children in the Comparison condition increased by two percentage points (see Table 6 and Figure 5). All of these effects were very small.

Table 6

Effect of condition and pre-test score on Community Helpers subscales at post-test (divided by response type)

	Pointing	1 or 2 Words	Phrase or Sentence
	B	b	B
Pre-test score on outcome	.50***	.80***	.64***
Pocoyo Treatment Condition (vs. Comparison)	.08	.39#	-.31*

Note: All are mixed models, with clustering of subjects by class.
# p < .10, * p < .05, *** p < .001.

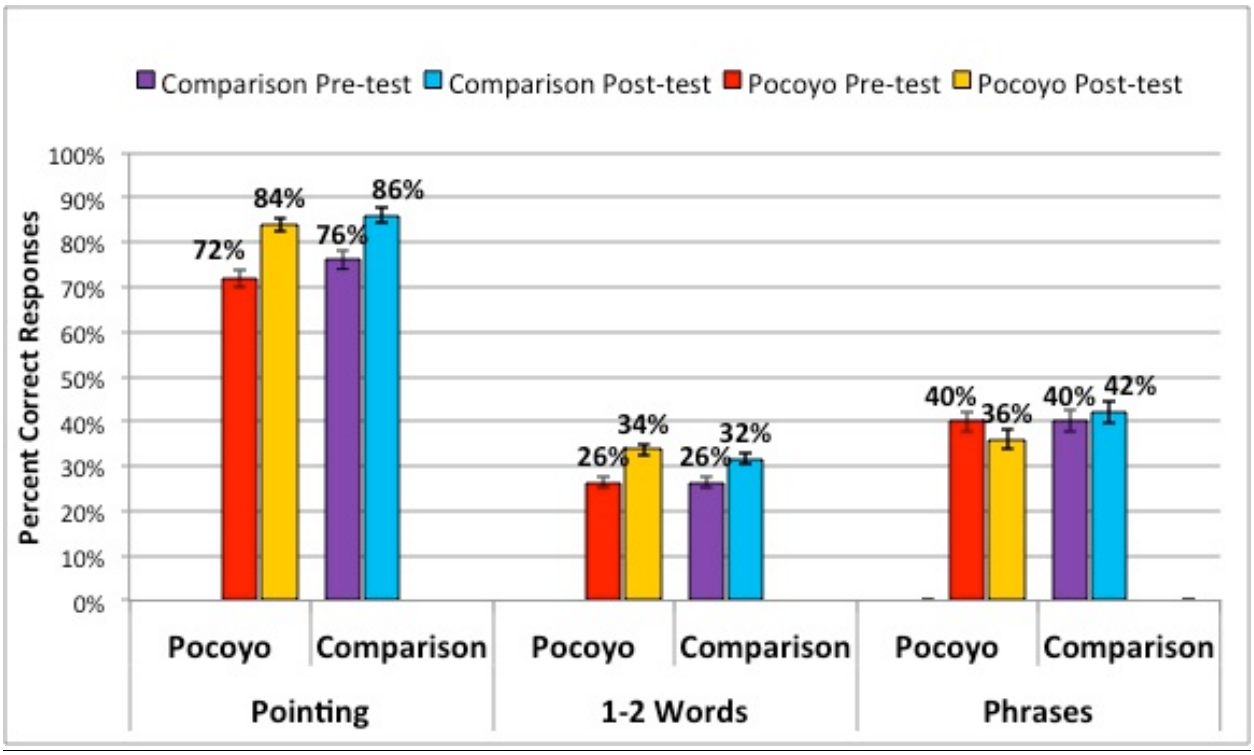

Figure 5. Community Helpers scores by condition, separated by response format

Detailed Findings: Effect of Intervention on *Get Ready to Read!* Scores

Get Ready to Read! scores were nearly identical for children in the *Pocoyo* Treatment and Comparison conditions (see Figure 6). There was some increase in mean scores for both groups, but regression modeling indicates no significant effect for condition on post-test scores (see Table 7). Additional moderator analyses were all non-significant: the lack of an effect for the *Pocoyo* Treatment condition on post-test *Get Ready to Read!* scores was consistent across all children regardless of their age, gender, prior degree of familiarity with *Pocoyo,* or pre-test scores on *Get Ready to Read!*.

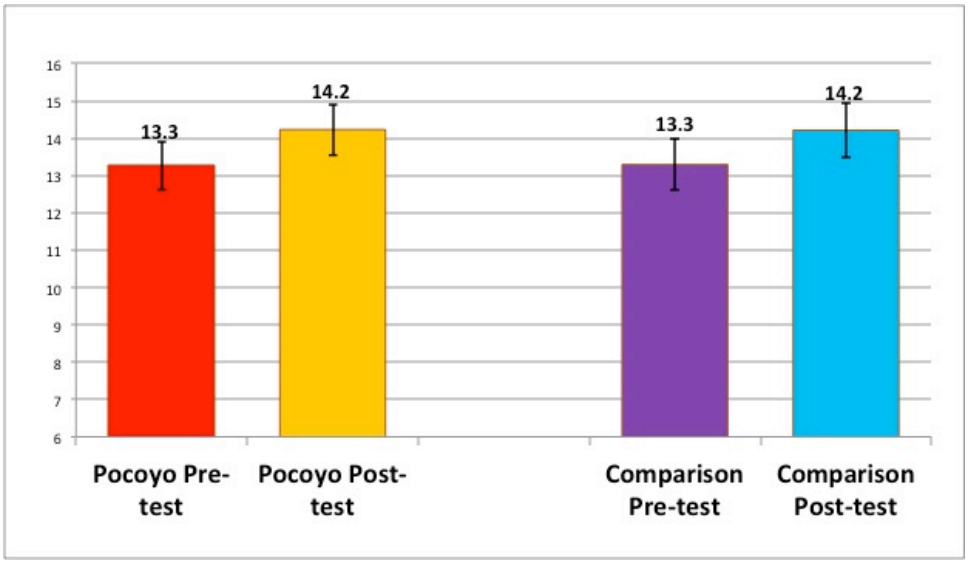

Figure 6. Get Ready to Read! scores by condition

Table 7

Effect of condition and pre-test score on Get Ready to Read! post-test score

	b	df	T	p
Post-test score	.85	1, 423	26.9	.001
Condition	-.04	1, 423	-0.1	.89

Post-hoc analysis: Removing children with difficulties during testing. Interviewer notes indicated that 60 out of 426 children (38 in the *Pocoyo* Treatment condition and 22 in the Comparison condition) had potential language barriers or behavioral issues (e.g., difficulty paying attention) that could potentially compromise the validity of the pre-test and/or post-test assessment. To determine whether these cases may have skewed the results, main effect analysis was repeated on the three main outcomes (*Get Ready to Read!*, *Community Helpers*, and total *Colors* scores) with these 60 cases excluded. Removing these cases did not substantially change any outcomes. Therefore these cases were not excluded and were left in the sample.

Comparison of Outcomes Across Domains (Colors and Community Helpers).

To enable comparison of the effects of the *Pocoyo* Treatment condition across curriculum (colors and community helpers) or study domains and to facilitate comparison with other studies, outcomes are expressed in standardized effect sizes (Cohen's d) in Figure 7. **The *Pocoyo* Treatment condition has a medium-sized positive effect on learning Uncommon Colors (d = .42) and a small positive effect on learning of Shades (d = .23).** The small negative effect on Color Mixing (d = -.20) was not statistically significant. Effects of the *Pocoyo* Treatment condition on *Get Ready to Read!* scores, knowledge of Community Helpers, and naming Basic Colors were negligible and not statistically significant.

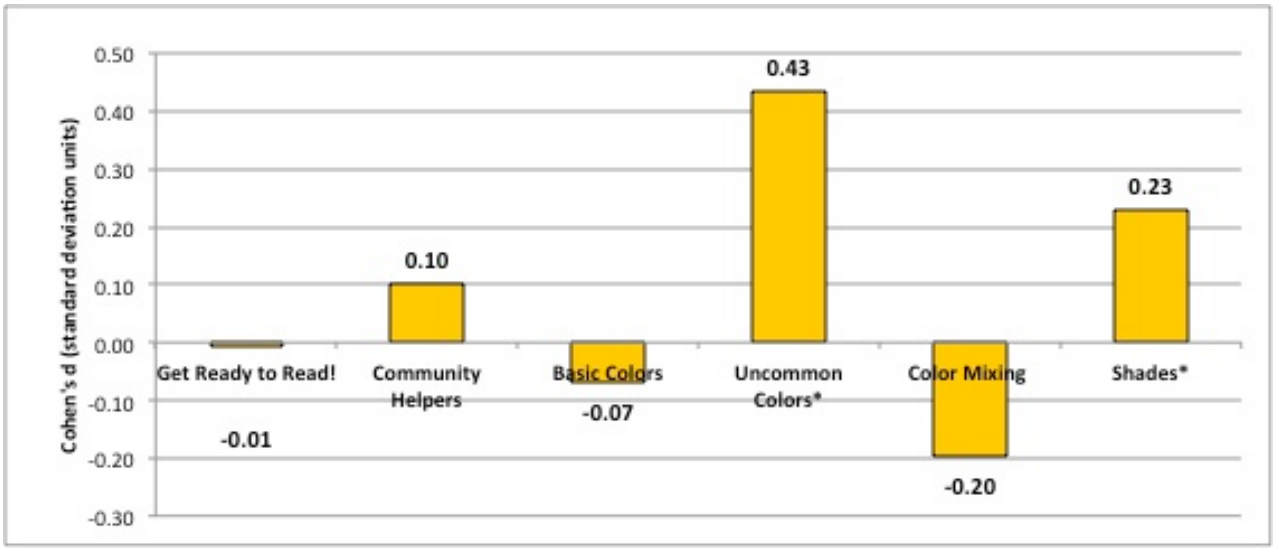

Figure 7. Effect sizes for outcomes of *Pocoyo* Treatment condition relative to Comparison condition

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*indicates a statistically significant effect

Findings from Teacher Logs and Structured Classroom Observations

Teacher logs, completed three times a week by all participating classroom teachers during exposure to the Treatment and Comparison materials, provide self-report data on children's use of study materials as well as teachers' perception of the relative appeal of the different materials for children. The completed logs, along with a structured observation during the placement period, confirm that the materials in both Treatment and Comparison classrooms were made available to and used by children. The materials were typically used during open or free play periods, when they were left on tables or in particular classroom activity centers, e.g., the puzzles with other puzzles, the books in the book area, etc.

Overall, teachers reported that they carried out some direct instruction with the materials, particularly with books and games that involved reading or some support from an adult. Specifically, in the *Pocoyo* Treatment condition, teachers' report of direct instruction during open or free play periods ranged from 25-30% and was often related to supporting children as they learned to use the apps or games and to reading the books provided. Similarly, in the Comparison condition, 30-40% of teachers reported doing some direct instruction during free or open play periods, most often related to the apps, books or a game that needed reading or initial teacher support.

Self-report findings from teacher logs and data from structured observations indicate that children enjoyed the materials. Teachers also reported overhearing children use the vocabulary from the materials. Teachers rated the appeal of particular materials based on their own observations of children's play in their classrooms. The most popular elements of the intervention materials among students in both conditions, and the ones they played with the

most, were the apps provided on the iPads. The majority of the materials were rated above a 3 on a 4-point scale, but the apps were rated highest in both conditions, followed by puzzles or books. (See Appendix C).

Data from the teacher logs confirm that materials provided for the Treatment and the Comparison conditions were regularly made available to children for use during free play. The findings also suggest a familiar and typical preschool pattern of a mix of self-initiated and teacher-supported activity, particularly when materials involve reading or instruction.

Conclusion

Relative to children in the Comparison group, children who used the *Pocoyo PlayGrounds* in the Treatment condition did not have significantly greater improvement in *Get Ready to Read!* scores, or in knowledge of concepts and vocabulary related to Community Helpers, although there were differences related to the items that required more or less verbalization for responses as well as having a language other than English spoken at home. The *Pocoyo* Colors *PlayGround* impacts knowledge about colors, but the effects were complex. There was no effect on total Colors response scores as whole. Children in the *Pocoyo* Treatment condition showed statistically significant improvement when compared to children in the Comparison condition in two areas – knowledge of uncommon colors, and knowledge about shades. Although these gains were statistically significant, the effects were modest.

Discussion

Children in both Treatment and Comparison Conditions showed positive gains between pre- and post-test in learning of early literacy skills and knowledge of vocabulary and concepts for colors and community helpers. The hypothesis that exposure to and interaction with *Pocoyo*

PlayGrounds is more efficacious in supporting early literacy development and promoting vocabulary acquisition in the topics covered than exposure to an alternative set of similar materials was not supported by overall findings. Analyses that compared outcomes for particular items or types of question (e.g., more and less familiar colors or different types of responses) did indicate differences between outcomes in the two conditions that point to several factors that influenced outcomes. These include: conducting the study towards the end of the school year and children's pre-existing knowledge of the curriculum content, the sample composition, the influence of local language conventions, and children's familiarity with touch screen technology. Each of these is discussed in turn.

Timing of Study. Fielding took place towards the end of the school year, beginning in late March and continuing through early June. As previously stated, knowledge of Basic Colors across the whole sample was relatively high at pre-test (about 85% correct), indicating near ceiling effects on these items. This is likely related to two factors: 1) the topic of colors being universally covered in preschool curricula; and 2) the timing of the study. By spring, participating children had received nearly a school calendar year's worth of exposure and, in most cases, instruction on basic colors.

Knowledge of Colors at Pre-test. The findings from item analyses on responses for Basic Colors compared with responses for Uncommon Colors, Color Shades, and Color Mixing indicate that there is a relationship between gains in knowledge and condition, as well as initial knowledge of colors at pre-test. The presence of ceiling effects with respect to Basic Color knowledge left little room for major differences on these particular outcomes. Further analyses provided findings that suggest differences between conditions for more advanced color

knowledge (e.g., uncommon colors like turquoise and lavender as well as color shades). Children randomly assigned to the *Pocoyo* Treatment condition showed significantly greater improvement than did children randomly assigned to the Comparison condition in knowledge of Uncommon Colors and Shades. When the analysis was re-run on the 15% of children who had limited knowledge of Basic Colors at pre-test, there was a trend (not significant) towards children in the *Pocoyo* Treatment condition not doing as well on color knowledge at post-test. It is possible that the more advanced content (Uncommon Colors, Shades) was beneficial to children who already knew Basic Colors, but may have been confusing to some children who were still learning names of more Basic Colors.

Local Language Conventions. For Community Helpers outcomes, it is important to note that many children were familiar with the community helpers depicted in the intervention stimuli and measures. Many were able to describe what they did and had their own vocabulary for them (e.g., "dog doctor" for "veterinarian," "cop" for "police officer"). It was not that they did not know about community helpers necessarily, but rather that they had other language for them. Ultimately, the language that is used by their families and in their communities prevailed during the exposure and assessment period.

Sample Composition and Languages Spoken at Home. The finding that outcomes are somewhat better on learning of community helpers' names for children who live in homes where a language other than English is spoken suggests that the presence of both Spanish and English in the *Pocoyo* Treatment materials may have been helpful to a subgroup of children who are either bilingual or living with two or more languages. The high percentage of children in the sample with a language other than English spoken at home (72%) was not anticipated,

and may also have had a pervasive impact on early literacy skills as well as vocabulary and concepts assessed.

Familiarity with Touch Screen Technology. Materials used in both the *Pocoyo* Treatment and Comparison conditions included touch screen apps related to the curriculum areas of community helpers and colors. Teacher reports indicate that the tablets were among the most appealing materials for children in both conditions. This raises the question of how familiar participating children were with touch screen technology. Findings from the Parent Survey indicate that the majority of children (92% of total sample) have been exposed to and use either tablets (65% in Treatment and 70% in Comparison conditions) or smartphones (62% for Treatment and 59% for Comparison Conditions). The implication is that lack of familiarity with touch screen technology was not an inhibiting factor or barrier to use of educational apps presented in Comparison or Treatment conditions. From the perspective of teachers in both conditions who rated the different materials for appeal to children, the apps were consistently scored as most appealing.

As with any study, there are factors that can be construed as limitations.

Timing of intervention during school year. A more extended and sustained exposure to the intervention stimuli (e.g., over the course of a term) might have resulted in more gains in the outcome measures. Conducting the study earlier in the school year would have allowed this. However, the study window was constrained by the realities of production schedules and the school year ending, with most preschools in the Northeast region of the U.S. ending their spring terms in May and early June.

Tracking of usage. The overall usage of the materials and specific use of individual elements was approximated through the use of teacher logs and structured classroom observations. Access to digital analytics would have enabled an additional layer of analysis comparing the activities within the apps that children engaged with the most with their learning outcomes. However, digital analytics were not available for any of the apps.

Sample composition unintentionally consisted of a larger percentage of Hispanic children. A sample reflecting more diversity would have been preferable. Further, the sample includes a large percentage of children who live in homes where a language other than English is spoken. This may have impacted study outcomes in several ways. It suggests that there are a number of children in the sample who are either bilingual or at least hearing more than one language. Bilingual children often take longer to acquire fluency and vocabulary in both languages (Magruder, 2012). The presence of many words in Spanish and English in the *Pocoyo* Treatment materials seems to have supported children's learning of Community Helpers terminology in the Treatment condition. However, the effect is small and a non-significant trend. In addition this is accompanied by a finding that children from homes where only English is spoken learned less Community Helpers terminology.

In summary, children in both conditions showed some gains in learning of early literacy skills as well as vocabulary and concepts related to the focal curriculum areas. Learning of uncommon colors and color shades was significantly greater for children in the Treatment Condition who were exposed to the *Pocoyo Colors PlayGround*.

The children's interest in and engagement with the apps or touch screen components in both conditions speaks to the appeal of this technology as a compelling platform for

supplemental learning. Transmedia materials can produce incremental gains in learning of basic pre-school skills, vocabulary and concepts, but the relative effectiveness and impact of these educational materials depend on a number of factors. More research is needed to explore the potential of digital educational media used in conjunction with other hands-on materials and experiences.

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