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Home Learning in the New Mobile Age: Parent-Child Interactions During Joint Play with Educational Apps

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HOME LEARNING IN THE NEW MOBILE AGE: PARENT-CHILD INTERACTIONS
DURING JOINT PLAY WITH EDUCATIONAL APPS

A Dissertation Presented

by

SHAYL GRIFFITH

Submitted to the graduate school of the
University of Massachusetts Amherst in partial fulfillment
of the requirements for the degree of

DOCTOR OF PHILOSOPHY

September 2018

Department of Psychological and Brain Sciences

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ABSTRACT

HOME LEARNING IN THE NEW MOBILE AGE: PARENT-CHILD
INTERACTIONS DURING JOINT PLAY WITH EDUCATIONAL APPS

SEPTEMBER 2018

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The rapidly increasing popularity of touch screen mobile devices, and accompanying educational applications (“apps”) targeted towards preschool children, calls for a new look at parent-child interactions around educational media. Research has shown that parental involvement in children’s educational media exposure can improve engagement and learning outcomes. However, to date little information is available on how parents navigate their children’s use of educational mobile technology, or how similar or different these interactions are to more commonly studied parent-child interactions, such as around shared reading. This study described, using observational data, parent-child interactions around educational apps and mobile devices in a sample of 36 families with preschool-aged children. The study further examined how the quality of parental behaviors (e.g., warmth, playfulness, parent engagement, and autonomy support) related to child engagement and affect during the interaction, and to children’s educational

achievement, and explored how parent-child interactions around educational apps compare to those around shared reading and joint play with a math toy. Higher quality parenting behaviors were related to higher child engagement and less negative affect during the app interactions, and to child engagement and positive affect during the shared reading and math toy interactions. High quality parenting behaviors in the shared reading and math toy tasks, but not the app tasks, were additionally related to child math and preliteracy scores. Parents' and children's roles during the app interactions differed from shared reading and math toy play tasks, particularly in that children took more of a lead role in the app interactions. This study represents a first step towards updating existing knowledge about parent-child interactions around home learning materials to include issues relevant to the new mobile age.

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CHAPTER 1
PARENT-CHILD INTERACTIONS AND EDUCATIONAL APPS

A. Introduction

The popularity of mobile technology has skyrocketed in the past five years, and for preschool-aged children and their families in the US across all socioeconomic classes, mobile technology is now part of everyday life. By 2014 in the US, over 85% of all parent-aged adults (18-34) owned smart phones, up from 25% in 2010 (Nielsen, 2014). Accordingly, the percent of children under age 8 with access to any “smart” mobile device in the home jumped from 50% to 75% between 2011 and 2013, and by 2013, 38% of children under age 2 had used a mobile device (Common Sense Media, 2013). In 2014, it was found that 97% of children in a low-income minority community used mobile devices, and three-quarters of children in that community had their own mobile device by age 4 (Kabali et al., 2015).

Educational mobile applications (“educational apps”) for children have likewise increased dramatically in availability in the past five years. Over 80,000 apps designated as educational or learning-based are currently available in the Apple store alone, and 58% of parents of children under 8 have downloaded apps for them (Common Sense Media, 2013). Preschool-aged children and their families are surrounded by educational media that are drastically different from any available before, and little is yet known about how parents navigate their children’s introduction to, and use of, mobile technology for educational purposes, or the effects of this on children’s early academic achievement.

It is widely recognized that the quality of the early home learning environment is heavily influenced by parent involvement, which in turn affects early academic interest

and achievement (Hill, 2001; Son & Morrison, 2010). For example, parents can foster preschoolers' academic interest and achievement by incorporating pre-literacy and pre-math concepts into everyday activities (Anders et al., 2012; Gunderson & Levine, 2011), by skillfully engaging in shared reading activities (Arnold, Lonigan, Whitehurst, & Epstein, 1994; Britto, Brooks-Gunn, & Griffin, 2006; Ortiz, Stowe, & Arnold, 2001), and by influencing the types and quantity of educational materials children are exposed to in the home (Christakis et al., 2013). However, research on the effects of parent involvement in at-home educational activities on emergent academic interest and skill has not yet been extended to home-based educational app use. Survey research has shown that children often use apps together with parents or siblings, and in fact that most young children prefer to play with someone else (Chiong & Shuler, 2010). The learning experiences offered by educational apps likely differ from educational TV and reading activities in that apps are inherently interactive, and can automatically scaffold children's learning (e.g., through built in prompts and individualization according to skill level; Hirsch-Pasek, 2015). Despite the ubiquity of mobile technology in young children's lives, we do not yet know how parents interact with their children around mobile educational technology in the home, nor do we know how these interactions differ from more frequently studied parent child interactions, such as around shared reading. This study is a first step towards updating existing knowledge about parent-child interactions and early academic development to include issues relevant to this new digital age.

B. Parent-Child Interactions During Shared Reading

Historically, research on parent-child interactions and young children's learning in the home has focused predominantly on shared reading as the context through which

parents' interactions with children can enhance early academic outcomes. (Gottfried, Schlackman, Gottfried, & Boutin-Martinez, 2015; Whitehurst & Lonigan, 1998; for reviews see Bus, van IJendoorn, Pelligrini, 1995; Fletcher & Reece, 2005). This research has demonstrated that it is not only the quantity, but also the quality of shared reading interactions that predicts children's engagement in reading activities, interest in reading, and later literacy development (Bus, Belsky, van IJendoorn, & Crnic, 1997; Fletcher & Reece, 2005; Sonnenschein & Munsterman, 2002). For example, research has pointed to the importance of positive and enjoyable parent-child interactions around reading for promoting children's reading engagement and interest, both of which have been described as mechanisms for later academic achievement (Sonnenschein & Munsterman, 2002). Two domains of parenting behaviors have been identified as particularly important for children's engagement, academic interest, and literacy outcomes: (1) the affective tone of the interaction, and (2) the quality of teaching or learning support provided by the parent (Landry et al., 2012).

Research has shown that when parents maintain a positive, warm, and responsive tone during shared reading interactions, children demonstrate greater interest in shared reading, and greater interest in reading later on (Leseman & de Jong, 1998). Parents' enthusiasm, engagement, and level of playfulness in interactions (i.e., the extent to which they can "make learning fun") has also been linked to greater child engagement and academic interest (Ortiz et al., 2001). Parents' use of praise and displays of positive affect during interactions are also linked to greater reading interest and engagement (Britto et al., 2006; Sonnenschein & Munsterman, 2002). Reading interventions that have been experimentally shown to improve parent reading behaviors, and children's engagement in

shared reading, train parents to respond with enthusiasm and to make reading together a fun activity (Landry et al., 2012).

Interventions aimed at maximizing the quality of parent-child interactions during shared reading also focus on parent behaviors that provide learning support for children (Arnold et al., 1994; Whitehurst & Lonigan, 1998). Dialogic reading, for instance, teaches parents to ask open ended questions about what they are reading, and to link content in the book to things relevant in the child's life (Arnold et al., 1994). Research has also demonstrated that responsive and autonomy supportive behaviors, whereby the parent responds to the child's interests and supports the child's developing independence, are linked to better engagement and learning outcomes, while parent intrusiveness or controllingness is related to poorer reading outcomes (Blewit & Langan, 2016; Bus & van IJzendoorn, 1988; Bus & van IJzendoorn, 1997). Parents can also support their children's learning during parent-child interactions by talking about letters, letter sounds, and vocabulary. The dialogic reading program, for example, prompts parents to label objects in the book frequently for the child, and to prompt the child to label objects by using "what" questions (Arnold & Whitehurst, 1994). Research further shows that greater amounts of extra-textual talk about letters and their sounds, and talk about new words and ideas, during shared reading are linked to greater vocabulary acquisition and greater gains in knowledge of print concepts (Justice & Ezell, 2002; Piasta, Justice, McGinty, & Kaderavek, 2012; Robbins & Ehri, 1994; Wasik & Bond, 2001).

C. Parent- Child Interactions and Early Numeracy Development.

Much of the knowledge on parent-child interaction quality during home learning activities has been derived from studies of shared reading, with far less focus on parents'

role in early mathematics development (Aubrey & Godfrey, 2003). A few existing studies have examined descriptively what parents do during math-focused play interactions with their children (e.g., scaffolding a child's counting skills by using joint counting), but have not linked this to math interest and engagement, or eventual math outcomes (Benigno & Ellis, 2004; Vandermaas-Peeler, Nelson, Bumpass, & Sassine, 2009). Research has shown, however, that parent-child interactions during everyday activities can have a large impact on preschool children's numeracy development (Anders et al., 2012; Blevins-Knabe & Musun-Miller, 1996). Parents incorporate numeracy concepts into activities at home such as cooking (Vandermaas-Peeler, Boomgarden, Finn, & Pittard, 2012) and shopping (LeFevre et al. 2009), and the extent to which they do this is related to children's math achievement (Anders et al., 2012; Gunderson & Levine, 2011; Levine, Suriyakham, Rowe, Huttenlocher, & Gunderson, 2010). No studies, however, have specifically looked at how parent-child interactions in play around math-focused toys or media are related to early math outcomes. This research gap is particularly notable given evidence that early math interest is a particularly strong predictor of later skills, and that early math skills are the strongest predictor of later achievement, even more so than early reading or attention skills (Duncan et al., 2007).

D. Parent-Child Interactions During Joint Use of Digital Media

The recent availability of educational digital media that allow children to interact directly with games on a screen raises the question of what the role of parents might be in these contexts. For example, what is the role of parents in providing a positive learning experience for children during mobile app use, given that educational apps may be able to provide direct instructional support and positive feedback for children through their

interactions with on-screen characters (Hirsch-Pasek et al., 2015)? Would children still benefit from adult support and adult interaction while playing educational games, or would parent involvement be distracting or superfluous? While there have been no studies thus far examining parent-child interactions around the use of educational apps, and how those might differ from shared reading and other at-home learning interactions, some existing research on parent-child interactions during television (TV) and e-book reading might inform research efforts in this area.

For example, research overwhelmingly indicates that high quality parent-child interactions during TV watching augment the degree to which young children learn from educational TV (Anderson & Pampek, 2005; Reiser, Tessmer, & Phelps, 1984). Strouse, O’Doherty, and Troseth (2013) recently found, for example, that children whose parents were trained to use dialogic questioning while co-viewing an educational TV show comprehended more and learned more vocabulary than children whose parents were not similarly trained, and hypothesized that the cognitive and social support provided by parents in the dialogic conditions served as mechanisms for these gains in learning. Similarly, Reiser et al. (1984) found that when parents were instructed to ask their children questions and provide them with feedback while watching Sesame Street, children demonstrated significantly more learning than a control group, where such instructions were not given. Segal-Drori, Korat, Shamir, and Klein (2010) also found that children who read electronic e-books with an adult showed greater improvements in word reading and decoding than children who read e-books with no adult, suggesting that adult support is still relevant in a digital format where children interact directly with stimuli on screen.

Studies of parent-child interactions during shared reading have also found differences in parent behaviors during joint reading in the traditional versus the e-books format. Krcmar and Cingel (2014) found that when reading electronic books with their children, parents talked more about the book format (e.g., commenting on animations) than in the traditional book format, and talked less about the content of the book, and that children's comprehension of the story in the e-book format was accordingly less. Korat and Or's (2004) study found that parents used more expanding talk, and evoked more child responses, in the print book format, compared to an e-book format. Kim and Anderson (2008), on the other hand, found that parents of preschoolers used more advanced and challenging patterns of speech, and increased labeling, with their preschoolers while reading an electronic book format, compared to the traditional book format. While this literature is still developing, it points to potential differences in parent behaviors during learning interactions across learning contexts, and underscores the importance of research examining parent-child interactions around new types of educational media.

CHAPTER II

THE PRESENT STUDY

The present study first describes, using observational data, parents' interactions with their children around educational apps. Previous research on shared reading and shared use of e-books suggests that factors such as what parents and children talk about during the interaction may be important (e.g., Krcmar & Cingel, 2014; Landry et al., 2012). Since this is the first observational study of parent-child interactions around educational mobile device use, information about how often children need help using apps or the touch screen, and how parents provide this help, is also presented to give a sense of how much procedural and physical help might be needed at preschool age. The study also describes several aspects of parenting quality with regard to parent-child interactions, including parenting behaviors regarding the affective tone of the interaction, and the quality of teaching and learning support behaviors. While there are many different variables that could be examined, as a first step this study examines variables that have support in the literature as being important for other parent-child learning interactions, including parenting warmth, parent engagement, playfulness, autonomy support. The study also examines how these parenting behaviors predict positive outcomes within the interaction, including child engagement and positive and negative affect, as well as children's academic achievement. Finally, the study examines how parent-child interactions around educational apps compare to parent child interactions around shared reading and joint play with a math toy.

Specifically, the study sought to answer the following questions:

1. How do parents and children in this sample interact while playing together with educational apps? Using descriptive statistics, specific questions included: (a) How much are parents and children, respectively, involved in the interaction, and what is the nature of this involvement? (b) What do parents and children talk about during the interaction? (c) How much do children need help from their parents, and how much do help do parents provide? (d) How do parent and child behaviors change across the interaction? and (e) How do parent engagement, playfulness, autonomy support, and warmth manifest in the app interactions?
2. How do parenting behaviors relate to child outcomes within the app interaction, and to children's academic development? I hypothesized that higher parent engagement, playfulness, autonomy support, and warmth would be related to higher child engagement and positive affect, and lower negative affect. I further hypothesized that higher quality parent-child interactions will be related to stronger early academic achievement scores.
3. How do app interactions compare with shared reading and math toy interactions? The study examined (a) How do ratings of parent and child behavior differ in the app task compared to a shared reading task and an interaction around math toy task, and (b) How do parent behaviors in the shared reading and math toy tasks, compared to the app tasks, relate to children's academic competence?

A. Method

1. Participants

Participants were thirty-six 4-year-old children (20 boys, 16 girls) and their families, recruited from Head Start and other preschool centers and birth record listings in western Massachusetts. The children were 4 years old at the time of the study ($M = 53.66$ months, $SD = 3.51$ months). Approximately half (52.8%) of the children were identified by their caregiver as white, 16.7% as bi- or multi-racial, 13.9 % as Latino or Hispanic, 11.1% as black or African American, and 5.6% of children as Asian. The primary caregiver participated in the study with the child. In this sample, they consist of 28 biological mothers, 5 biological fathers, 1 foster mother, 1 adoptive mother, and 1 grandmother. The median annual household income for the sample was \$42,000. Approximately half (47.3%) of the primary caregivers in the sample had earned a bachelor's degree or higher, 16.6% earned an associate or vocational degree, and 36.1% earned a high school diploma/GED.

2. Procedure

Participants were recruited through local Head Start centers and community preschool centers, as well as birth record listings for western Massachusetts. Two-thirds of the participants ($n = 24$) were originally recruited as part of a three-month experimental study examining the effect of using high quality educational apps on early academic skills in low-income families. These participants were therefore primarily low income and were recruited largely from Head Start centers. These participants completed a pretest visit and a posttest visit 3 months later. Data from the pretest visit were used in this study. The remaining participants ($n = 12$) were recruited primarily from state birth

record listings, and were from low, middle, and high income families. These families completed a single visit that was identical to the pretest visit for the other families.

Data for this study were collected during one home visit, which lasted approximately two hours. Parents were asked to complete questionnaires about their child's media use, their attitudes towards the use of media for educational purposes, and their child's academic and socio-emotional functioning. Children simultaneously completed assessments of pre-literacy and pre-math skills.

Parents and children then completed four observation tasks, in which they were videotaped reading a book, playing with a math toy, playing a pre-literacy app loaded on an iPod touch®, and playing a math app on the same device for 5 minutes each. Parents were given the following instruction: "Here is a book (toy/app) for you and (child) to read (play with)." They were then alerted when the 5 minutes was up, and prompted to end the task. If parents indicated that they or their child were finished with the task before 5 minutes had elapsed, they were allowed to end early. Average length of the interactions used in the study are as follows: book task (M = 285.64 seconds, SD = 47.82), math toy (M = 292.09 seconds, SD = 39.55), reading app (M = 275.06 seconds, SD = 54.80), and math app (M= 282.00 seconds, SD = 49.23). The book used for the shared reading interaction was *I Love You, Blue Kangaroo* by Emma Chichester Clark. This book is rated for children ages 4-8. A set of 50 plastic counting bears in 5 colors with 5 matching colored cups from the brand Eureka were used for the math toy.

The pre-literacy and math apps used for these tasks were *Bob's Books #1: Reading Magic* and *Drive About: Number Neighborhood*, respectively. *Bob's Books #1: Reading Magic* is rated for ages 4+, and is a storybook app that prompts players to

combine letters to make up short words, which make up a sentence. When the user touches the letter, the letter sound is emitted, and the user must drag the letter into the correct place to spell the word. As each word in the sentence is filled in, the corresponding object in the picture is filled in with color, until the entire picture is in color and animates. The user can choose among four levels, which offer decreasing levels of support (e.g., the first levels have outlines of the letters and only allow the user to place the letters over the outlines in any order to spell the word, while the final level has no outlines and requires the user to spell the word in the correct order).

Drive About: Number Neighborhood is also rated for ages 4+. In the app, the player moves a car with their finger through a seaside neighborhood and can stop at various points to access math-based activities (i.e., mini-games) that involve numbers, counting, ordering, and matching. Nine different activities are available in this app: (1) Whale Feeding, where users use a slingshot to feed a whale the correct number of pieces of food, (2) Cloud Writing, where users trace numbers in the sky, (3) Snowboard Slalom, where users guide a yak down a slope by touching flags in numerical order, (4) Catch-a-Sea-Pickle, where users tap on sea pickles with the target number on them, and avoid tapping on others, (5) Space Vacuum, where users use a vacuum to collect the correct number of a given object (e.g., marbles), (6) Paint-by-Numbers, where users fill in a painting in color by matching numbers (7) Cookie Bakery, where users match shapes to decorate a cookie, (8) See-Saw, where users balance a see-saw by placing the correct number of animals on either side, and (9) Construction Blocks, where users stack blocks in order starting from the lowest number. The user can enter any of the mini games from

the main screen which shows the neighborhood, and can return to the main screen by pressing a return button.

The 24 families in the three-month experimental study received an iPod touch with educational apps after completing the posttest, while the remainder of families that completed a single visit received \$40 in compensation for their participation in the single 2-hour visit.

3. Measures

Parent-Child Interaction Observations

Videos of the parent-child interactions were coded by a group of nine research assistants. Coders were trained by the first author. Training took place during weekly meetings over a period of four weeks. A subsample of videos from this study were used for training purposes. During training, coders watched videos of each type of interaction task (book, math toy, and app) and practiced coding independently. All discrepancies were then discussed as a group. Training was complete when ICCs above .7 were obtained among the group. Each video was then coded independently by two coders, and the average of the coders' scores was taken. The subsample of videos used for training were recoded after the training period also by two coders. During the coding process, major discrepancies occurring between coders were discussed; however, the coders' original scores were not changed.

Parent-child interactions were coded globally to capture parents' warmth, playfulness, engagement, and use of autonomy support, and child engagement in the app, shared reading, and math toy tasks. ICCs for these global codes were .78 for parent warmth, .78 for parent playfulness, .76 for parent autonomy support, .82 for parent

engagement, and .74 for child engagement. A composite app interaction score for each global code was created by averaging the scores for each parent-child dyad across the math and the pre-literacy app tasks.

Parent Warmth

Coders rated the extent to which parents' interactions with their children were warm versus hostile, harsh, or detached on a scale of 1 (not at all warm) to 7 (very warm). Coders were instructed to consider the extent to which parents displayed a warm presence (e.g., warm tone of voice and facial expressions), acted in a caring or sensitive manner towards the child, and displayed affection.

Parent Playfulness

Coders rated the frequency and skill with which parents made efforts to make learning fun during the parent-child interaction, on a scale from 1 (not at all playful) to 7 (very playful). Coders were instructed to attend to the extent to which parents used an expressive or entertaining voice, emphasized the fun aspects of the task, and laughed or joked with the child, and, conversely, the extent to which parents focused on task completion in a dry or unembellished way.

Parent Engagement

Coder rated the extent to which parents were engaged in the task, on a scale from 1 (very detached) to 7 (very engaged). Coders were asked to attend to parents' enthusiasm, attention, and apparent interest in the task, and to any signs of parent boredom or detachment from the task or the child.

Parent Autonomy Support

Coders rated the extent to which parents took interest in and acknowledged the child's perspectives, preference, and choices, and supported the child's developing autonomy during the task, on a scale of 1 (controlling) to 7 (very autonomy supportive). Coders were asked to attend to both high autonomy supportive behaviors (e.g., encouraging the child to take part in decisions during play, verbally acknowledging the child's intentions during play), and to low autonomy support or controlling behaviors, such as intrusiveness, use of frequent directives, or giving help that is not needed.

Child Engagement

Coders also rated the extent to which children were engaged in the task, on a scale from 1 (not at all engaged) to 7 (very engaged). Coders were asked to attend to signs such as attention to the task, enthusiasm and interest in the game, and body postures such as leaning in as opposed to leaning away from the task.

The parent-child interaction videos were also coded in intervals of 10-seconds to capture the frequency of child positive and negative affect. The parent-child interaction videos for the app tasks were additionally coded in 10 seconds intervals for the content of parent and children's talk during the interaction, the extent to which children needed help and the type of help given, and the way that parents and children navigate holding the iPod and using the touch screen during the joint interaction. A composite score for each interval code was created by averaging the scores for each parent-child dyad across the math and the pre-literacy app tasks.

Child Positive and Negative Affect

These codes were used to indicate whether a child expressed positive affect (e.g., smiles, excited exclamations) or negative affect (e.g., whining, expressions of frustration,

sad expressions) within each 10-second interval. The overall scores used in inferential analyses were the percentage of total intervals in which positive affect and negative affect, respectively, were coded. For descriptive purposes, an average count of positive and negative affect during the 10 minutes of combined math and reading app interactions was also calculated by multiplying this percentage by 60. The ICC for these codes were .93 for positive affect and .83 for negative affect.

Content of Conversation

Coders indicated whether the parent, or child, or both, talked about: (1) the app (features of the app or procedures for playing the game), (2) literacy content (letters, letter sounds, or vocabulary words), and (3) math content (numbers, quantities, or math concepts) during each interval. Coders also indicated if parents asked open-ended questions during the interval. The percentage of intervals in which the parent and child, respectively, talked about the app, literacy content, and math content were taken as the total scores. The percentage of intervals in which the parent asked open-ended questions was taken as the total score for this code. ICCs for the parent and child codes, respectively, were .78 and .69 for talking about the app, .92 and .91 for literacy content, and .97 and .93 for math content. The ICC for the open-ended questions code was .78.

Device and Touchscreen Use

Coders indicated whether the child, the parent, or both, held, helped to hold, or stabilized the iPod Touch at any point during each 10-second interval. Coders also indicated whether the child, the parent, or both, used the touchscreen during the interval. The overall scores were the percentage of total intervals in which the child and parent,

respectively, held the iPod and used the touchscreen. ICCs for each of these codes fell between .98 and .99.

Help Needed/Given

Coders indicated whether children indicated that they needed, or appeared to need, help during each interval, and coded whether they needed help with: (1) how to use the app, (2) academic content, or (3) using the touchscreen. Coders also indicated whether parents provided help in each interval, and indicated whether the help given was in the form of: (1) verbal instruction, (2) hand over hand guidance, or (3) demonstration. The percentage of coded intervals was used as the total score for each of these codes. For descriptive purposes, an average count of positive and negative affect during the 10 minutes of combined math and reading app interactions was also calculated by multiplying this percentage by 60. For each of the needing help codes, ICCs fell between .85 and .88. For the giving help codes, ICCs were .86 for verbal instruction, .95 for hand over hand guidance, and .95 for demonstration.

Pre-Literacy Skills

Children's pre-literacy skills were assessed using the Test of Preschool Early Literacy (TOPEL; Lonigan, Wagner, Torgesen, & Rashotte, 2007). The TOPEL is designed to measure emergent literacy in 3- to 5-year-olds. This test consists of three subtests measuring print knowledge, vocabulary, and phonological awareness. The print knowledge subtest assesses print concepts, letter-name and letter-sound identification, and letter and word discrimination. The vocabulary subtests assess spoken vocabulary and knowledge of word definitions. The phonological awareness subtest assesses word awareness and phonemic awareness, including word and phoneme elision (i.e., saying the

word that is left after a part of the word is taken away) and blending (i.e., putting sounds together to make a word). Normed standard scores (with a mean of 100 and a standard deviation of 15) are calculated for each subtest, and for an overall composite score. Internal consistency for each of the subtests was estimated between .86 and .96, and the TOPEL has good test-retest reliability (.91) and inter-rater reliability (.98; Lonigan et al., 2007).

Pre-Math Skills

Children early math skills were assessed using Form A of the Test of Early Mathematics Abilities-3 (TEMA; Ginsburg & Baroody, 2003), which measures math performance in children 3-to 8-years old. This test measures knowledge of formal and informal math concepts, including relative magnitude, counting, calculation, and number facts. The initial questions focus largely on numeracy (i.e., identifying numerals and counting the number of objects on the page). The TEMA-3 has good psychometric properties and includes a wide range of items at the early stages of math development. A normed standard score (with a mean of 100 and a standard deviation of 15) is calculated for an overall composite score. Ginsburg and Baroody (2003) have demonstrated the TEMA-3's validity in both its relation to other standardized measures and its ability to identify children who are struggling in math. The test-retest reliability of the TEMA-3 is estimated to be .82.

4. Data Analytic Plan

To describe how parents and children in this sample interacted during joint educational app use, frequencies of interval-coded child and parent behaviors (child positive and negative affect, content of conversation, help needed by child, help given by

parent, and device and touchscreen use), and means for globally coded behaviors (parent and child engagement, parent playfulness, parent warmth, and parent autonomy support) were examined for the app interactions. Additionally, interactions with high scores in each of the parenting behavior codes were selectively transcribed to show “exemplars” of each parenting behavior in the context of interactions around educational apps. Finally, to examine how the frequency of coded behaviors changed over the duration of the app interactions, 10-second intervals were combined into 6 consecutive time blocks (of 50 seconds each). Coded behaviors in each block were summed to create a score for that block. Within-subjects ANOVAs were performed to test for differences in the frequency of coded behaviors among the 6 blocks, and follow up trend analyses were performed when the omnibus ANOVA indicated significant differences among the blocks.

To compare child and parent coded behaviors in each of the three learning contexts (shared reading, math toy, and educational apps), within-subjects ANOVAs were performed for each of the variables that were coded across all three tasks (parent engagement, parent warmth, parent playfulness, parent autonomy support, child engagement, child positive affect, and child negative affect). Follow up pairwise comparisons were then performed between the app condition and the other two conditions when the omnibus ANOVA indicated significant differences.

To examine how parenting behaviors related to child outcomes within the app interaction, and to children’s academic development, child outcome variables (child engagement, child positive affect, child negative affect, and children’s TEMA and TOPEL scores) were regressed separately on parenting quality variables (engagement, playfulness, warmth, and autonomy support) in each task. These parenting quality

variables were selected for analysis given previous literature showing that they are important for parent-child learning interactions. In each regression analysis, child gender, age, maternal education, and total household income were added simultaneously as control variables.

CHAPTER III

RESULTS

A. Mobile Device Ownership and App Use in the Sample

Thirty-three of the 36 families (91.67%) in this study reported owning at least one smartphone or tablet, and all (100%) of the families that owned mobile devices reported that their 4-year old used the devices. Time spent by children on mobile devices, for children who used them, averaged 52 minutes per day ($M = 52.12$, $SD = 57.47$). Parents were asked to report their children's favorite activities on the mobile devices, and activities reported included playing educational and non-educational app games (e.g., ABC123, Hungry Hippos, basketball game), watching videos (e.g., YouTube or Netflix), taking photos, and playing music. Twenty-four of the 36 (66.67%) parents indicated that they downloaded apps specifically for their child. Twenty-six out of the 36 parents indicated that they had rules about their child's screen time. Rules concerned the amount of screen time allowed (41.67%), when (16.67%) and where (2.78%) screen time was allowed, expectations of good behavior to access screen time (13.89%), restrictions on content (8.3%), and stipulations that an adult must be present while the child is accessing screen content (5.56%).

B. How Do Parents and Children Interact when Playing Jointly with Educational Apps?

1. Parent and Child Involvement and Roles in the App Interaction

Results showed that on average children held the iPod Touch and used the touchscreen for most of the app interaction, while parents spoke twice as often as children (see table 1). Children held the iPod Touch during 66% of the intervals, and used

the touch screen during 86% of the intervals, while parents held the iPod Touch during 38% of intervals, and used the touch screen during 20% of intervals. Parents spoke during 66% of the intervals, while children spoke during 31% of the intervals. Interactions were rated to be more child-led than parent-led ($M = 5.31$, $SD = .86$). The extent to which interactions were child vs. parent led differed by gender of child: boys ($M = 5.60$, $SD = .65$) were rated to lead tasks significantly more than girls ($M = 4.90$, $SD = .98$), $t(32) = -2.53$, $p = .016$. Boys ($M = .18$, $SD = .11$) also displayed more positive affect than girls ($M = .09$, $SD = .08$), $t(32) = -2.44$, $p = .02$, and girls ($M = .11$, $SD = .10$) received more help via demonstration than boys ($M = .05$, $SD = .07$), $t(33) = 2.13$, $p = .04$. There were no other significant differences based on gender.

2. Affective Tone and Engagement

Overall, children were rated as highly engaged during the app tasks ($M = 5.35$, $SD = .70$). On average, child positive affect was coded during 14% of intervals ($M = .14$, $SD = .11$), and child negative affect during 2% of intervals ($M = .02$, $SD = .03$), while parents positive affect was coded during 16% of intervals ($M = .16$, $SD = .10$), and parent negative affect during less than 1% of intervals ($M = .002$, $SD = .009$).

3. Talk During App Interactions

Across math and reading app interactions combined, parents spoke more about reading concepts than math, $t(34) = 2.18$, $p = .04$, and this difference for children was marginally significant, $t(34) = 1.98$, $p = .06$ (see Table 1 for means). In order to investigate the proportion of academic and non-academic talk that occurred during each task, the following analyses were conducted with math and reading app interactions separately. As expected, during math app interactions, parents and children spoke more

frequently about math ($M = .13$, $SD = .14$ and $M = .05$, $SD = .08$) than reading concepts ($M = .001$, $SD = .005$ and $M = .00$, $SD = .00$), $t(31) = 4.95$, $p < .001$ and $t(31) = 3.36$, $p = .002$. During reading interactions, parents and children spoke more frequently about reading ($M = .21$, $SD = .20$ and $M = .09$, $SD = .12$) than math concepts ($M = .006$, $SD = .02$ and $M = .003$, $SD = .01$), $t(34) = 6.12$, $p < .001$ and $t(34) = 6.12$, $p < .001$. During math app interaction, children and parents both spent a greater proportion of intervals talking about the features of the app ($M = .16$, $SD = .17$ and $M = .38$, $SD = .19$) than talking about math concepts ($M = .04$, $SD = .08$) and ($M = .13$, $SD = .15$), $t(31) = 3.25$, $p = .003$, and $t(31) = 5.80$, $p < .001$, respectively. This was not the case for the reading app interactions. During the reading app interactions, children and parents did not spend significantly different proportions of intervals talking about the features of the app ($M = .10$, $SD = .11$ and $M = .22$, $SD = .14$) than talking about reading concepts ($M = .10$, $SD = .12$ and $M = .22$, $SD = .20$), $t(34) = .15$, $p = .88$, and $t(34) = .09$, $p = .93$.

4. Needing and Providing Help

Children were rated as needing help with how to use the app on average during 17% of intervals ($M = .16$, $SD = .13$), with gestures for the touchscreen during 6% of intervals ($M = .06$, $SD = .07$), and with academic content during 3% of intervals ($M = .03$, $SD = .06$). Parents gave verbal assistance to children during 28% of intervals ($M = .28$, $SD = .15$), gave help via demonstration during 7% of intervals ($M = .07$, $SD = .09$), and gave help via hand over hand assistance during 2% of intervals ($M = .02$, $SD = .03$). Parents use of verbal assistance was positively correlated with children needing help with academic content ($r = .42$, $p = .01$) and app navigation ($r = .38$, $p = .03$), but not with needing help with the touchscreen. Parents use of hand-over-hand guidance and

demonstration was positively correlated with children needing help with the touchscreen ($r = .42, p = .01$; and $r = .50, p = .002$), but not with their needing help with academic content.

5. Change in Behaviors Across Interaction

Linear trend analyses indicated that the frequency with which children needed help with how to use the app ($F(1, 29) = 29.59, p < .001$), and the frequency with which parents gave help verbally or by demonstration, significantly decreased as the interaction progressed ($F(1,29) = 15.76, p < .001$ and $F(1, 29) = 7.21, p = .01$). Parents holding of the device ($F(1,29) = 6.5, p = .02$) and use of the touchscreen ($F(1,29) = 8.12, p = .008$) also decreased across the interaction, while parent's asking of open ended questions increased ($F(1,29) = 5.37, p = .03$).

6. Parenting Quality

The means for the app interactions were as follows: Warmth ($M = 4.36, SD = .65$) Playfulness ($M = 3.94, SD = .81$) Autonomy Support ($M = 4.66, SD = .76$) and Engagement ($M = 5.02, SD = .83$). Presented below are “exemplars” of each parenting behavior in the context of interactions around educational apps.

1. *High Parent Playfulness*. The 5-minute interaction from which this excerpt was taken was rated 5.5 on a scale of 7 for parent playfulness.

Mother: Put your finger on the green ball. Pull it back.

[Child tries unsuccessfully]

Mother: Can I... it's hard. Here, you want mom to show you?

Child: Yes *[Removes hand from screen and tilts screen towards mother]*.

Mother: *[Demonstrates and sends food flying into whale's mouth]* Wooooo!

[Child and mother giggle] Isn't that awesome? You gotta feed the whale!

[Child tries successfully]. There you go! *[Child giggles].*

...

Child continues playing and wins the round. Celebratory sounds from the app.

Mother: *[eyes wide, exaggerated facial expression]* Woah!

2. *High Parent Autonomy Support.* The 5-minute interaction from which this excerpt was taken was rated 6.5 out of 7 for parent autonomy support.

Mother: Let's see, which one should we do here? *[clicks on something]* Ah!

This is the one that you know how to do already. *[child continues to look silently at the game]* Look it down here! Look, you tell me. Is this the right place for the 'p'? *[child continues to look at the screen, but does not respond]* Should I put it there? *[mother moves 'p' closer to its box]*

Child: *[whispers]* Yes

Mother: *[moves 'p' closer to box]* There?

Child: *[whispers]* Yes

[Mother puts the 'p' in the correct box]

Mother: This is like the game you know how to play on the iPad already.

Child: *[whispers]* Your turn.

Mother: What comes next? We'll take turns.

Child: *[whispers]* "I"

Mother: "I"? Ok, where should the "I" go?

[child moves the “I” after two tries]

Mother: Ok. You or me?

[child reaches to move the “g”]

Mother: Ok

[Child moves the g to the correct box]

App: [celebratory sound] Pig!

Mother: Yay! [child watches screen with hands in lap] Oh! Which way do you want to go, this way or that way? [points]

[Child taps something on screen]

Mother: That way? OK.

3. *High Parent Engagement.* The 5-minute interaction from which this excerpt was taken was rated 5.5 out of 7 for parent engagement.

[child taps on a 9]

Mother: [playfully]That’s not a two! [whispers anticipatory noises when the 2’s appear] Oh! There’s one!

[child plays successfully while mother watches over his shoulder]

Mother: You’re good at this! Is there one left?

[child gets last 2]

Mother: [whispers] Yes! [gives child a pat on the stomach when the screen shows he has completed the task].

App: Tap the number 8 on the sea pickles!

[child begins scanning screen]

Mother: Do you see any 8s?

[child finds one]

App: Yes!

[child scans again]

Mother: Mmm. C'mon 8!

[child taps an 8]

App: Yes!

[child scans again]

Mother: Any more?

[child scans and gets another one]

App: Yes!

Mother: They are trying to trick you. Where's another 8? [laughs] They're very fast.

4. *High Parent Warmth.* The 5-minute interaction from which this excerpt was taken was rated a 6 out of 7 for parent warmth.

[Child and mother are lounging on the couch next to each other, with their heads resting together. Child is makes an incorrect move on screen.]

Mother: [softly] Oops.

[Child tries again successfully]

Mother: That's it. [raises her head to look at child's face, then back to the screen]

Mother: [murmurs encouragingly] One more.

[Child wins the round]

Mother: [in an impressed voice, with a smile] Very good! [pats the child's leg]. What number is this?

Child: Four!

Mother: [smiles] Very good!

C. How do App Interactions Compare with Shared Reading and Math Toy Interactions?

Intercorrelations among coded parent behaviors in the three tasks (app, shared reading, and math toy) are presented in table 2. Intercorrelations among coded child affect and engagement variables are presented in table 3. Children were rated as being more in charge of the app tasks ($M = 5.33$, $SD = .87$), compared to the shared reading tasks ($M = 2.31$, $SD = 1.02$), $t(33) = 15.05$, $p < .001$, and marginally more in charge in the app tasks compared to the math toy task ($M = 4.81$, $SD = 1.31$), $t(31) = 1.79$, $p = .08$. Children were rated as more engaged in the app tasks ($M = 5.37$, $SD = .71$) than in the shared reading task ($M = 4.86$, $SD = 1.27$), $t(33) = 2.35$, $p = .03$., but parents were rated as warmer and more playful in the shared reading task ($M = 4.76$, $SD = .71$, and $M = 4.73$, $SD = .97$, respectively) than in the app task ($M = 4.37$, $SD = .66$ and $M = 3.94$, $SD = .84$), $t(33) = 3.52$, $p = .001$ and $t(33) = 4.34$, $p < .001$. Children displayed more positive affect in the math toy task ($M = .22$, $SD = .18$) compared to the app task ($M = .14$, $SD = .11$), $t(31) = 3.31$, $p = .002$, and displayed more negative affect in the app task ($M = .02$, $SD = .03$) compared to the shared reading task ($M = .006$, $SD = .02$), $t(33) = 2.52$, $p = .02$.

D. How Does the Quality of Parenting Behaviors Predict Child Affect and Engagement?

Child engagement, child positive affect, and child negative affect were regressed separately on parenting quality variables in each task (engagement, playfulness, warmth, and autonomy support), controlling for child gender, age, maternal education, and total household income (see Table 4). For the app tasks, parent autonomy support was related to higher child engagement, and parent engagement, playfulness, warmth, and autonomy support were all associated with less child negative affect, controlling for demographic variables.

For the shared reading task, parent engagement and autonomy support were related to higher child engagement during the task, controlling for demographic variables. For the math task, parent engagement was related to higher child engagement and marginally related to higher child positive affect, parent playfulness was significantly related to higher child engagement and child positive affect, and parent autonomy support was also marginally related to both higher child engagement and child positive affect, after demographic variables were controlled. Parent warmth was not significantly related to child engagement or affect outcomes in the shared reading or math toy tasks.

E. How do Parent-Child Interactions Relate to Academic Achievement?

Academic outcome variables were then regressed on each parenting quality variable, again controlling for child gender, age, maternal education, and total household income (see Table 5). With demographic variables controlled, parent engagement and playfulness in the shared reading task were positively related to children's phonological awareness, while parent autonomy support in the math toy task was marginally positively

related to children's early math skills and print awareness. Parent playfulness in the math toy task was negatively related to children's phonological awareness. Quality of parents' behaviors during the app tasks were not significantly related to children's early academic skills.

F. Descriptions of Child Negative Affect during the App Interaction

Of the affect and engagement outcomes measured, child negative affect was most consistently predicted by parent behaviors in the app task. In order to further examine the occurrence of negative affect during the app interactions, the four videos with the highest child negative affect scores for the math and reading app tasks, respectively, were examined separately by two observers. In particular, attention was paid to parent-child interactions in the videos before, during, and after, instances of child negative affect and the following common themes were identified by both coders. Negative affect during the interaction appeared to result from: (1) not having the choice of what to play on the iPod, (2) the task being too far above the child's skills level, and/or (3) parent intrusiveness. Examples of each of these themes were transcribed and presented below.

1. **Wanting to play a different game.** *Mother and child have just finished the interaction task with the reading app, and have switched to the math app. The mother has the device in her hands and is trying to figure out how to play the new game.*

Child: [frowns] Not this!

[Mother shows child something on the screen]

Child: [whining voice] What? No, not this one!

Mother: [continues to show child the game]. Look at that.

Child: No, the other games! The other one!

2. **Parent intrusiveness.** *Mother:* [pointing] It says, Dot has a hat!

[Mom takes child's hand and guides it towards screen to tap on the hat]

Child: Stop! [Pulls his hand out of mother's grip]

[Child repeatedly taps on the hat, then the letter 'a']

[Mother grabs child's hand, lets it go, then points at screen]

Mother: You gotta spell –

Child: Stop! [leans forward away from mother and hunches over the device, blocking the screen from her view]

3. **Task too far above child's skill level.** *Mother and child are playing with the math app. The mother next to the child and holding the iPod in front of the child. The child's hands are in her lap.*

Mother: Ok. Do you see the toppings on the side? We're going to decorate a cookie. Can you find – let's see – you gotta touch it-
(demonstrates, has difficulty moving the shape, frowns) Hm. I'm not sure –

[Child reaches in and tries unsuccessfully. Mother tries again and is successful]

Mother: Oh, there we go. You gotta touch it and drag it.

[Child puts her finger on the touchscreen and tries to move a shape]

Mother: (under her breath) I don't know why the flower is not going.

[Child continues to try unsuccessfully to move different shapes three times]

Mother: Yea. There you go. You got the circle one.

[Child tries two more times]

Child: *[whining voice]* I can't do it *[puts hands back into lap]*

Mother: *[reaches in and moves the shape successfully]* It's a little bit hard.

[Child tries again once then puts hand back in lap]

Mother: *[puts a finger on the touch screen]* Oh I got it! Can you do it for me?

[Child tries again]

Mother: Put your finger right on it –

Child: *[frustrated tone]* I can't! *[puts hands back in lap]*

CHAPTER IV

DISCUSSION

The present study described parent-child interactions during joint educational app use using observational data, examined relations between parental behaviors and child affect and engagement, and provided some comparison between co-use of educational apps and shared reading and joint math play interactions. Results showed that both parents and children in the sample were involved in the app interactions, though they had different roles. Children lead the interactions and interacted directly with the screen while parents contributed to the interaction verbally, and provided help to the child. In general, parents' main role was that of helper and commentator. Parents' and children's roles during the app interactions differed from shared reading and math toy play tasks, particularly in that children took more of a lead role in the app interactions.

Results further suggest that parent behaviors identified as being important for improving engagement and outcomes in other learning contexts, such as shared reading, may also be important for joint use of educational apps. In this study, parent autonomy support was related to higher child engagement during the app tasks. Additionally, better parenting quality on all domains measured (parent engagement, warmth, playfulness, and autonomy support) was associated with lower negative affect. These findings are consistent the research showing that parents' behaviors during shared reading predict children's positive engagement in the activity (Landry et al., 2012; Ortiz et al., 2001), and extends knowledge in this area to include parent child-interactions around other home learning materials.

Results also suggest that while some knowledge from shared reading literature is likely applicable to parent-child co-use of educational apps, there may be some areas in which new knowledge is needed. One way in which app interactions appear to differ from shared reading interactions is that children, rather than parents, are ‘in charge.’ Our knowledge about parenting behaviors during learning activities in the home at this age is based largely on shared reading where, because most children cannot yet read, parents are often leading the interaction. Although our interactions showed that children still require adult assistance, especially at the beginning of encountering a new game, they tend to lead the interaction rather than the parents. Indeed, parent intrusiveness may be particularly likely in this learning context to lead to negative affect, given these roles. However, in general, the parenting behaviors shown to be important to child engagement and interest in reading tasks were also shown to be important to interaction outcomes during the app tasks.

For the app tasks, parenting behaviors predicted negative affect most consistently, while for the shared reading and math toy tasks, parenting behaviors did not significantly predict negative affect. This suggests that, perhaps more than in tasks where parents are more in the lead, one of the roles that parents play during joint app play is helping to decrease negative affect. Alternatively, it suggests that, with children being in the lead on these tasks, less skillful parents run the risk of getting in the way of their children’s play and causing frustration. Indeed, analysis of the causes of negative affect in the interactions shows that negative affect occurred from parent intrusiveness, not having choice, and task frustration. Research should continue to examine parents’ roles in decreasing negative affect in this learning context.

In the observation tasks, children were required to switch from one app to the other after 5 minutes, and parents prompted them to stay with that one app for the full 5 minutes. When children did not have the choice of switching back to the app they wanted, or trying a different one, expressions of negative affect occurred. This suggests that it might be important for children to have this level of autonomy as well, and to have multiple small games that they can switch between to maximize engagement. For example, apps with mini games or activities within an app might be important for keeping a child's attention over time. Additionally, parental assistance in switching back and forth between games may be important for maintaining engagement. Research is needed to further examine the ideal length of a game to keep children at this developmental level engaged, and whether switching back and forth between games impacts learning. Mismatch between demands of the game and the child's skill was another reason for negative affect, and is one area that parents' skills might especially be needed to bridge the gap for children, to prevent frustration. Parents might need to choose levels for the children according to their skill, and to provide instructional support particularly when they first begin using them.

Parenting quality was related to some academic outcomes in the reading and math toy tasks, but not the app tasks. There are many possible explanations for this finding, particularly given how much is still unknown about apps as educational media. For example, shared reading may still be a more common home learning activity than use of educational apps. Indeed, children's use of apps may not typically be educational. Effects of parents' behaviors might therefore take longer to manifest and not be captured in a cross-sectional study. There may have also been parent behaviors that do impact

children's academic outcomes that were not measured during the app interactions in this study. However, it is notable that parent behaviors during shared reading and math toy interactions in this study were related to academic outcomes while those in the app interactions were not, suggesting that parent-child interactions around apps might be meaningfully different from interactions around shared reading. Much more is known about what parent behaviors best foster later academic skill in the shared reading context, and it is notable these relations may not necessarily directly apply to the educational apps. This study did not directly examine whether parenting behaviors during this app task had an effect on children's ability to learn from the app, and this is an area in which further research is needed.

A. Preliminary Implications

While it is premature to describe empirically-based guidelines for parents on how best to interact with their children around educational apps, these results are a step in that important direction. Results suggest that, as has been found in other learning contexts, parents do impact the quality of the experience. Findings also suggest, for example, that it may be helpful to encourage parents to support their children in learning how to use apps, while also being careful not to intrude on children's autonomy. Parents might also benefit from instruction regarding providing higher initial levels of support as children first learn a game, but then allowing more child autonomy as game logistics are mastered. The results of the study also add to the evidence from other at home learning context literatures that parents' involvement can impact children's engagement with educational media, even in contexts where the learning might seem at first glance to be an individual activity (e.g., as with TV and mobile apps).

B. Limitations and Future Directions

This study offered preliminary descriptions of parent-child interactions around a joint educational app task; however, there were limitations. First, while videotaped interactions occurred in the families' homes, they were structured tasks in which parent and children were given directions about the interaction, and parents and children interacting with an unfamiliar app. We do not know how closely these interactions mirror those that take place more naturally in the home, or with apps familiar to the child and parent. Additionally, our study only examined two apps. We averaged observations across these two app interactions for most analyses to reduce the likelihood that observations were app specific, but it is possible that other apps would elicit different interactions between parents and children. Second, interactions with educational apps lasted for 10 minutes and occurred at one timepoint, and this study was therefore not able to examine variables such as how long interactions between parents and children might last. Third, given the cross-sectional nature of the study, relations between parenting variables and child outcomes in the future could not be examined, and causal conclusions could not be drawn. For instance, we were unable to examine whether relations between parenting behaviors and child engagement and affect were due to effects of the parent on the child, or vice versa, or both. Fourth, our sample was small, and did not allow for enough power to inferentially examine more complex relations among the study variables. For example, we were not able to examine whether socioeconomic status might have moderated the relationships between parenting behaviors during the app interaction tasks and child outcomes.

Future studies should collect further information about naturalistic interactions that occur between parents and children in the home, and how these might evolve over time. Future studies are needed to build on the current study to determine whether parenting behaviors during joint use of educational apps affect children's learning from these apps, and to create guidelines for parents regarding best practices for interacting with children around this medium. Additionally, research is needed to examine how using educational apps with their children might support parents' ability to engage with their children around academic concepts. This might be particularly useful in the case of mathematics, which parents report feeling less competent at teaching (Cannon & Ginsberg, 2008). Indeed, in this study parents talked more about reading concepts than math concepts during the app interactions, which might speak to parents' greater comfort with reading based tasks.

Future research should also attend to individual differences in the ways that parents and children interact around educational apps. For example, in this study boys were found to have taken a greater leading role in the interactions than girls, and girls were given more help than boys, despite their equal achievement scores. Given societal messages to girls that they are less competent than boys, this could be important to address, though conclusions about these gender differences remain speculative until further research is conducted. With bigger sample sizes, future studies might examine how individual child differences such as gender and academic competence might impact children's needs during the interaction.

C. Conclusion

This study provided initial descriptive information about parent and child interactions around educational apps. Results suggest that parents play an important helping role in joint use of these apps with their children, and that their parenting behaviors are related to child affect and engagement within the learning interaction. Additionally, results of this study suggest that while affective parenting concepts such as playfulness and warmth that are important in the reading literature are also important in joint app use interactions, teaching behaviors such as autonomy support may manifest differently due to the child-led nature of the app interaction compared to shared reading. More research is needed to determine what types of apps best support children's learning, and to delineate specific strategies for parents to foster children's learning from digital media.

Table 1: Parents and Children’s Activities during the App Interactions

	Parent <i>M (SD)</i>	Child <i>M (SD)</i>
Holding the iPod	.38 (.37)	.66 (.38)
Using the touchscreen	.20 (.15)	.86 (.17)
Speaking	.66 (.18)	.31 (.19)
Talking about the app and its features ^a	.29 (.14)	.12 (.10)
Talking about reading content (letters, letter sounds)	.12 (.12)	.05 (.07)
Talking about math content (numbers, counting)	.06 (.07)	.02 (.04)
Gives verbal instructions	.28 (.15)	-
Gives hand-over-hand guidance	.01 (.03)	-
Demonstrates for child	.07 (.09)	-
Needs help with content	-	.03(.06)
Needs help with procedures	-	.17 (.13)
Needs help with touchscreen	-	.06 (.07)

Note. Values displayed represent the proportion of intervals in which activity was observed.

Table 2: Descriptive Statistics and Intercorrelations of Rated Parent Behaviors during the App, Shared Reading, and Math Toy Tasks

Parent Variable	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
<u>App Tasks</u>												
1. Engagement	-											
2. Playfulness	.71**	-										
3. Warmth	.50**	.82**	-									
4. AS	.33 [†]	.38*	.35*	-								
<u>Shared Reading Task</u>												
5. Engagement	.20	.46**	.54**	-.03	-							
6. Playfulness	.22	.50**	.57**	.07	.85**	-						
7. Warmth	.12	.49**	.63**	.14	.79**	.80**	-					
8. AS	.10	.09	.24	-.29 [†]	.43**	.48**	.39**	-				
<u>Math Toy Task</u>												
9. Engagement	.009	.32 [†]	.45**	.26	.37*	.33 [†]	.21	.007	-			
10. Playfulness	.25	.62**	.71**	.12	.51**	.54**	.53**	.07	.70**	-		
11. Warmth	.16	.67**	.79**	.26	.52**	.51**	.66**	.08	.45**	.74**	-	
12. AS	.12	.46**	.48**	.27	.40*	.33 [†]	.37*	-.16	.26	.12	.26	-
<i>M</i>	5.02	3.94	4.36	4.66	5.29	4.62	4.71	5.01	5.22	4.50	4.39	4.91
<i>SD</i>	.83	.81	.65	.76	.90	1.07	.72	.79	.77	1.05	.86	1.12

**p < .01, *p < .05, [†]p < .10. Note. AS = Autonomy Support.

Table 3: Descriptive Statistics and Intercorrelations of Rated Child Engagement and Affect during the App, Shared Reading, and Math Toy Tasks.

Child Variable	1.	2.	3.	4.	5.	6.	7.	8.	9.
<u>App Tasks</u>									
1. Engagement	-								
2. Positive Affect	.21	-							
3. Negative Affect	-.07	.21	-						
<u>Shared Reading Task</u>									
4. Engagement	.26	-.19	.02	-					
5. Positive Affect	.38*	.34*	-.12	.33*	-				
6. Negative Affect	.32 [†]	.53**	-.02	-.26	.41*	-			
<u>Math Toy Task</u>									
7. Engagement	.31 [†]	.34 [†]	-.03	.40*	.34 [†]	.23	-		
8. Positive Affect	.15	.66**	-.22	-.30+	.38	.35*	.24	-	
9. Negative Affect	.13	.09	.42*	.05	-.02	-.02	.05	-.15	-
<i>M</i>	5.35	.14	.02	5.46	.21	.02	4.81	.13	.01
<i>SD</i>	.70	.10	.03	.99	.02	.06	1.25	.11	.02

**p < .01, *p < .05, [†]p < .10. Note. M and SDs for positive and negative affect are presented as ratio of intervals that positive or negative affect was coded as present.

Table 4: Relations among Parenting Behaviors and Child Engagement, Positive Affect, and Negative Affect during Parent-Child Joint Play with Educational Apps, Shared Reading, and Play with a Math Toy

Parent Behaviors	Child Engagement	Child Positive Affect	Child Negative Affect
<u>App Tasks</u>			
Engagement	.28	-.009	-.39[†]
Playfulness	.18	.18	-.47*
Warmth	.05	.03	-.52**
Autonomy Support	.40*	-.07	-.41*
<u>Shared Reading Task</u>			
Engagement	.48*	.12	.009
Playfulness	.23	-.002	.16
Warmth	.18	.06	.08
Autonomy Support	.36*	.08	-.17
<u>Math Toy Task</u>			
Engagement	.53**	.35[†]	.19
Playfulness	.51*	.56**	.18
Warmth	.19	.18	-.12
Autonomy Support	.45[†]	.35[†]	-.37

[†] $p < .10$, * $p < .05$, ** $p < .01$. Note. Coefficients are standardized regression coefficients when child outcome variables are regressed on parent behaviors, controlling for child age, gender, maternal education, and household income.

Table 5: Relations among Parenting Behaviors in the App, Shared Reading, and Math Toy Tasks and Children’s Academic Competence

Parent Behaviors	TEMA	TOPEL	Print	Vocabulary	PA
<u>App Tasks</u>					
Engagement	-.31	-.15	-.15	-.02	-.16
Playfulness	-.10	-.14	-.04	-.05	-.21
Warmth	.06	-.08	.02	-.06	-.12
Autonomy Support	.13	.13	.21	.05	.05
<u>Shared Reading Task</u>					
Engagement	-.02	.22	-.03	.22	.40*
Playfulness	.11	.33[†]	.19	.19	.48*
Warmth	-.01	.12	.02	.01	.29
Autonomy Support	-.31	-.03	-.12	-.14	.22
<u>Math Toy Task</u>					
Engagement	.06	.04	.20	.07	-.14
Playfulness	-.14	-.20	-.01	-.03	-.45*
Warmth	.01	-.07	.02	-.04	-.14
Autonomy Support	.42[†]	.23	.40[†]	.30	-.16
<i>M</i>	99.00	98.89	100.94	100.14	97.61
<i>SD</i>	14.39	15.03	14.89	15.27	13.41

[†] $p < .10$, * $p < .05$, ** $p < .01$. Note. Coefficients are standardized regression coefficients when child academic outcomes are regressed on parent behaviors, controlling for child age, gender, maternal education, and household income.

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