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ABSTRACT

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The presence of digital mobile applications (apps) designed to promote early literacy skills has surged in the last few years. This study explored children's affect and engagement as they interacted with three apps: *Endless Reader*, *Hideout: Early Reader,* and *Preschool Matching Game: Rhyming Words*. The study consisted of 12 children, age 4 to 5, who interacted in pairs with each of the apps while their classroom teacher facilitated the experience. The researchers examined videos and transcripts of the children's actions and nonverbal expressions as they encountered the apps. Transcripts included verbal and nonverbal information with codes assigned to represent child behaviors. Descriptive analysis of the data led to characterizing behaviors children exhibited in light of the different apps' design features and with respect to group dynamics.

The researchers found that all three apps had relatively equal proportions of positive and negative child behaviors. However, the types of behaviors varied according to the demands and constraints of each app. The researchers also observed differences in child behavior depending on the dynamics that occurred as children interacted with each other and with their teacher. The results of the study imply that parents and teachers seeking to choose quality apps must consider a variety of factors, including the type of child engagement that the app tends to elicit and the instructional value of the content. Future research should explore the extent to which different types of positive and negative behaviors are related to design and pedagogical features of apps in order to aid parents and teachers in choosing apps that are engaging as well as instructionally sound.

Keywords: applications, iPad apps, early literacy, engagement, affect

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CHAPTER 1

Literature Review

With an increase in availability of educational applications (apps) on mobile devices and their popularity with young children, educators often seek to use apps to support the development of early literacy skills. Evaluations of the instructional quality of early literacy apps are critical as teachers rely on them more and more as supplemental instructional mechanisms. While much has yet to be learned in terms of the nature of these apps and their effectiveness, some information does exist. As a start, it is important to draw upon principles of child engagement in early literacy instruction with the idea of using these principles to determine the instructional efficacy of early literature apps, and create guidelines for selecting quality apps.

Principles of Engagement

Effective instruction of early literacy skills, regardless of whether the medium is print or digital, incorporates principles of child engagement. Some of these principles include eliciting different levels or types of engagement, utilizing strategies to engage children in the instruction, and determining the level of engagement observed in children during instruction.

Types of engagement. Quality early literacy instruction takes into account the various levels of engagement needed for children to learn the skills they need. One level of engagement to consider includes cognitive engagement. According to Hirsh-Pasek et al. (2015), engagement at the cognitive level means children should be focused and actively involved in thinking through the tasks and experiences presented through instruction. In addition, Hirsh-Pasek et al. state that cognitive engagement goes beyond the capacity to physically manipulate objects and encounter entertaining graphics. The extent to which children become cognitively engaged in developing and practicing skills determines how well they are able to learn the early literacy skills presented

during instruction. For example, if children are actively involved in a discussion throughout an activity as opposed to passively listening, they are more likely to remain cognitively engaged throughout the activity.

Another level of engagement to keep in mind during instruction is social engagement. Culatta, Black, and Hall-Kenyon (2013) point out that social exchanges during play enrich children's learning experiences. As such, engagement not only involves focus and thought, but also includes the degree of social interaction which occurs during instruction. Vaala, Ly, and Levine (2015) comment that social engagement in relation to apps can include children interfacing with characters in an app, communicating with other people through the app, and collaborating while sharing a device. Engagement on a social level whether virtually or in person is an important factor to consider when examining child engagement during literacy instruction.

In addition to cognitive and social engagement, instructors should also consider the level of affective engagement. Axelrod and Hone (2006), who examined affective responses during computer interaction, claim that affective engagement is a significant factor due to the role emotion plays in allowing people to make choices on a day-to-day basis. One study examined the influence of teacher affect (e.g., tone of voice and dramatization) on student affective response during read aloud experiences with stories (Moschovaki, Meadows, & Pellegrini, 2007). Moschovaki et al. concluded that teacher use of affect can help children in understanding stories and in developing intersubjectivity. Paying attention to the degree of affective engagement during early literacy instruction can help teachers improve the quality of child learning of the literacy skills and can help improve basic skills such as problem solving.

Strategies of engagement. In addition to understanding the types of engagement, it is important to recognize different strategies for eliciting child engagement. One strategy includes utilizing changes in tone and facial expressions. The teacher's tone of voice and facial expressions used while reading texts can influence children's responses towards the text and attitudes towards reading in general (Moschovaki et al., 2007). Moschovaki et al. also suggest that the teacher's affect plays a role in children's affective engagement during read-aloud experiences.

Another strategy for eliciting child engagement involves the use of spectacles and music. Parette, Hourcade, and Blum (2011), in a study involving animation in PowerPoint presentations, comment that the use of visuals and animation during instruction can increase attention and improve prompts designed to elicit correct responses. Music allows for repetition and practice in a way that is pleasant for children (Culatta et al., 2013) and provides opportunities for increasing child motivation and engagement in social interactions (Thompson & McFerran, 2015). Having children sing along adds a level of authenticity and makes the experience more holistic (Jalongo & Ribblett, 1997). Incorporating music into reading instruction can foster positive memories associated with reading and can improve the learning experience (Copeland & Martin, 2016).

In addition to using intonation, spectacles, and music, teachers can also pay attention to child interests and motivation as a strategy for increasing child engagement. Oliveira (2015) comments that children interpret texts according to their individual experiences, which means that including texts that reflect children's interest can increase child engagement and improve the learning experience. Weih (2014), in a study involving student responses related to reading instruction, found that child engagement increased when students were motivated by content which they found interesting.

Determining level of engagement. Besides the principles of examining types of engagement and utilizing strategies for increasing engagement, teachers should also pay attention to how to determine children's level of engagement. Axelrod and Hone (2006) comment that one method of measuring affective engagement lies in coding behaviors such as facial expressions. Ponitz and Rimm-Kaufman (2011) measured cognitive engagement by examining focused attention, using computer software to determine the number of seconds a child spent on-task versus off task. Moschovaki et al. (2007) determined level of child engagement in shared reading experiences by examining affective responses of children such as repetitions of phrases from the task, dramatizations of scenes from a story, and comments expressing emotions related to a task. It is a challenging task to measure child engagement, but researchers such as those mentioned above have employed successful methods of examining engagement.

Instructional Efficacy of Early Literacy Apps

With an abundance of apps, and a goal to implement effective ways to integrate technology into instruction, educators are faced with the challenge of maintaining best teaching practices while allowing students to gain potential benefits from technology. Current research indicates that efficacy of digitally-delivered material in classrooms is dependent on the extent to which the instructors embed content delivered via the app into the larger curriculum, fit the apps to a focused purpose, capitalize on social interactions around the app, and provide scaffolding.

Embed into the curriculum. The quality of instruction involving early literacy apps is affected by the extent to which they decide how to incorporate them into the curriculum during their planning. Many teachers who typically strive for excellence and best practices in their classroom instruction forget to implement those same standards when delivering instruction through digital media (Israelson, 2015). They may assume that the apps are self-sufficient

without realizing that efficacy of instruction utilizing early literacy apps requires careful planning. Israelson addressed the issue of integration by developing a planning framework that consists of a process for effectively planning literacy instruction by taking into account evidence-based practice in instruction regarding content and integration of technology. According to the Israelson, the first step of choosing apps to support literacy instruction consists of identifying instructional and literacy objectives, considering the needs of the students, and determining the level of scaffolding required to support students.

In addressing the need for careful planning in utilizing early literacy apps in instruction, Northrop and Killeen (2013) proposed that instruction using iPads should begin with teaching the literacy skill without the use of the iPad, followed by direct instruction of how to use the app, including an explanation of the app with modeling and guided practice using the app. Fletcher-Watson (2015) claims that choosing technology based on sound theoretical educational principles will lead to more effective instruction of the targeted skills. Whatever the method teachers choose for utilizing technology in their instruction, the emphasis should be on incorporating technology into the curriculum as a means to enhancing the literacy skills established in the curriculum.

Fit with a focused purpose. While the possibilities for adding an additional context for learning is great with the use of iPad apps, teachers must approach instruction involving technology with a purpose. According to Lee and Kim (2015), teachers should choose apps based on the degree to which they connect to the skills and concepts targeted in the curriculum and use mobile devices as a means of extending the learning from the classroom into virtual experiences that have meaning. When choosing an app to address literacy skill, such as recognizing and decoding phonic patterns, the teacher may also want to consider how

implementation of the app could be used to encourage creativity, problem-solving, cooperation, and independence. Researchers in Australia (Lynch & Redpath, 2014) engaged in a two-year study in which they observed a classroom teacher who used a combination of apps with games targeting literacy skills, apps with interactive e-books, and productivity apps for story making to foster independence and creativity in addition to supporting skills. In the study, iPad apps were used as tools for expanding on concepts taught in traditional instruction while providing an avenue for children to work creatively and independently. The teacher reported successful engagement of students in independent learning with iPads, particularly in a project where the students made an alphabet book.

Capitalize on social interactions. Whenever possible, effective instruction involving early literacy apps should encourage social interactions around the app. Instructors should facilitate interactions through small groups where children share the iPad in multiplayer or single player activities or through virtual interactions facilitated by tools within the app.

According to Wohlwend (2015), adults should choose apps according to the degree to which they encourage cooperation through the use of multiplayer interactions or open-ended interactions promoting collaboration. Wohlwend also comments that adults can facilitate collaboration and cooperation among children during play with apps in a manner similar to the encouragement of collaboration among children in imaginative play using objects such as action figures and dolls. Whether the play occurs with real objects or with a virtual scenario in an app, teachers can facilitate social interactions among children in order to help them develop early literacy skills and language skills required for collaborative activities.

In addition to facilitating activities with apps involving multiplayer roles, teachers can also encourage interactions among students who share a device without the platform of more

than one player. Teachers often encourage student cooperation centered around classroom materials and activities in order to practice early literacy skills, but they can also facilitate cooperation among small groups of students sharing a device. In fact, student interest in the technology may even cause an increase in conversations among students about early literacy principles as was the case in a study where Hutchison, Beschorner, and Schmidt-Crawford (2012) found that the use of iPads in instruction provided opportunities for increased collaboration among students and facilitated better conversations among students about the early literacy topics. Teachers must, however, use caution in forming groups in order to provide the best opportunity possible for learning, as large groups may cause individuals to disengage from the app, leading to a decrease in opportunity for practicing skills (Melero, Hernández-Leo, & Manatunga, 2015).

In an extension of face-to-face peer interactions around an app, some developers have created or arranged for virtual interactions that utilize tools on the iPad that allow for individual users to communicate or share content with other users digitally. These types of tools allow students to share content in the form of audio, video, pictures, and text in order to communicate ideas in a way which expands on traditional communication in person and which allows students to practice cooperative learning while increasing in academic-based skills (Ebrahim, Ezzadeen, & Alhazmi, 2015). One study found that when given the opportunity to read electronic books independently, students utilized features of the app to leave written messages for other students to view later in order to communicate their thoughts and opinions about the books and allow others to share in their experience (Hutchison et al., 2012). Whether the communication takes place in real time or in the form of messages, virtual interactions carefully facilitated by teachers

can allow students to gain valuable experience with early literacy skills while participating in social interaction centered on an app.

Scaffold access. In addition to arrangement of opportunities for social interactions, the quality of instruction utilizing iPads is dependent on the presence of scaffolding provided by the parent or teacher. Scaffolding includes adult support of the early literacy concepts in the form of modeling and feedback in order to ensure that children are understanding the skills taught and learning at their level.

One important aspect of adult scaffolding includes support in the form of modeling. Northrop and Killeen (2013) suggest that meaningful opportunities utilizing apps to teach early literacy skills must begin with careful modeling of the targeted early literacy skills before use of the app, followed by modeling of the skills within the app. They caution teachers to utilize scaffolding to ensure that children have a strong understanding of the early literacy concepts and the function of those skills within the app before allowing students to use the app independently. Modeling includes commenting on and asking questions about targeted skills within the context of the app in order to draw children's attention to the important concepts while encouraging critical thinking and problem solving (Neumann & Neumann, 2014). Apps can be very useful in allowing children to receive practice with literacy skills, but teachers need to provide scaffolding through modeling and questioning strategies to ensure that children gain a sound understanding of the targeted skills.

In addition to modeling of the early literacy skills using comments and questions, adults should also provide scaffolding in the form of feedback. As adults guide children through the practice of early literacy skills in an app, feedback regarding children's successes and struggles with those skills is essential in ensuring that they truly understand those skills and do not develop

misconceptions (Northrop & Killeen, 2013). Reinforcement can also help children expand their skills develop higher order problem solving abilities (Neumann & Neumann, 2014). When adults support children's interactions with the app by providing encouragement and specific feedback, they help motivate children and allow for an experience which fits each child's individual abilities (Hirsh-Pasek et al., 2015). Although reinforcement built into the app itself can be important in motivating and guiding students through practice of the skills, the addition of adult feedback can allow children a personalized experience not possible with the app alone.

The design of touch screen devices, including portability, their interactive nature, and their resemblance to books, lends itself to stimulating early literacy skills; however, much is required in terms of providing scaffolding to children while using the apps in order to ensure that they effectively learn early literacy skills (Neumann & Neumann, 2014). Appropriate scaffolding including modeling and feedback can help children receive quality instruction as they practice skills through apps.

Guidelines for Choosing Early Literacy Apps

In addition to concerns about how to best approach instruction utilizing digital media, teachers and parents are also faced with the challenge of how to select quality apps out of the myriad of products labeled educational. Although there is not one clear-cut resource available for parents and teachers, researchers have attempted to begin the process of establishing guidelines to help adults choose apps, including evaluating apps based on the quality of engagement, relevance, content, and feedback provided within the app.

Relevance and context. Another important characteristic of quality early literacy apps includes providing relevant, contextualized experiences. Apps which promote skills connected to meaningful experiences, such as games and texts with familiar characters and story lines or

content related to the child's life, will be more effective in teaching skills than those apps focused solely on drill and practice activities, especially when the content allows children to make connections to their life (Hirsh-Pasek et al., 2015). The apps teachers choose should be authentic and relevant, allowing students to gain significant experience with the targeted skills in ways that build on prior knowledge while helping children make connections to new concepts (Lee & Kim, 2015). Providing an authentic experience also means that the app allows children to practice skills with a purpose, in meaningful ways which encourage the child and increase desire to keep practicing the targeted skill (Culatta, Hall-Kenyon, & Bingham, 2016). The most effective apps will provide a virtual representation of authentic contexts to which children can relate, allowing them to make connections to prior knowledge and build knowledge of skills in meaningful ways.

Appropriate research-based content. In addition to selecting apps which provide relevant contexts, teachers should also look for apps which contain appropriate content that is based on research. Appropriate research-based content includes concepts which are accurate and which meet the needs of the child individually.

While teachers may assume that apps, especially those with high ratings, contain accurate and appropriate information, it is up to the teacher to carefully select apps which meet their expectations. It's important for teachers to review the app before adopting it in order to verify that it does not contain inaccurate or developmentally inappropriate information (Northrop & Killeen, 2013). Apps claiming to teach early literacy skills may contain errors in the content or may use abstract, demanding, or distracting concepts (Culatta et al., 2016). Some apps may even contain inaccurate information, examples with errors, or content that is biased or outdated which can confuse children and prevent them from learning (Ok, Kim, Kang, & Bryant, 2016). The

accuracy of the concepts presented in the apps will affect how well children learn targeted early literacy skills, and it is up to the teacher to ascertain whether or not the apps they select contain accurate information.

In addition to verifying that the information of the apps is accurate, teachers must also determine whether the app meets the individual needs of the children. Hartle and Berson (2012) advocate that adults use current best practices regarding the developmental level, age, culture, interests, and ability of each individual child when selecting apps to use with children. Lee and Kim (2015) also suggest choosing apps that are appropriate in terms of the degree to which they match the cognitive abilities of the children they target. They encourage teachers to look for apps which provide opportunities for developing creativity and problem-solving skills in ways which are consistent with children's level of development. The individual needs of the children using the app, as well as current research in child development, must be considered when selecting appropriate apps.

App developers often do not include information about the research or evidence-based claims regarding the quality or efficacy of their app on the description posted on the App store (Vaala et al., 2015). Due to the unavailability of research information for most apps, teachers must carefully use their best judgement in attempting to select apps that are accurate, free of errors, and appropriate to the developmental level and needs of the child.

Quality modeling and reinforcement. In addition to verifying the accuracy of the content in an app, teachers should also look at the quality of reinforcement provided within the app. Inadequacies in the level and type of modeling and feedback provided in the app could detract from the app's ability to be used as a tool for teaching appropriate skills (Culatta et al., 2016). Ok et al. (2016) suggest that quality feedback within an app includes positive

reinforcement for correct answers and identification of incorrect response with an explanation of why it is incorrect and modeling of a correct response. They also comment that quality reinforcement is essential to allowing children to have successful experiences with targeted early literacy skills without perpetuating and reinforcing mistakes. When implementing guidelines for selection of quality apps, it is essential that teachers choose apps with built in scaffolding including modeling and reinforcement.

Engagement. According to Noorhidawati, Ghalebandi, and Siti Hajar (2015), effective child engagement with apps involves elements of attention, physical manipulation of the device and interaction with the device, and emotional reactions to the app. Noorhidawati et al. also comments that observations of verbal and nonverbal child behaviors can help in determining the quality of child engagement with an app. Teachers hoping to choose quality early literacy apps should look for apps which effectively teach a targeted skill in a manner which is engaging without becoming distracting (Israelson, 2015). Apps which contain audio and graphics which are disorganized or distracting can detract from the learning experience and inhibit children in effectively gaining the targeted literacy skills (Ok et al., 2016). As a result, teachers must carefully choose apps which meet the requirement of being cognitively and emotionally engaging without inserting elements which may detract from the learning experience.

Summary

Given that teachers faced with the task of effectively utilizing apps in instruction of early literacy skills may feel overwhelmed, the need is great for researchers to continue to study the efficacy of early literacy apps in order to establish guidelines for selection and use of such apps. The little research that exists regarding such guidelines suggests that teachers must be mindful of the types of apps they select from the multitude of apps available in order to choose the best

possible tools for instruction. Teachers must use caution in order to ensure instructional efficacy while utilizing apps, including making efforts to embed content delivered via the app into the larger curriculum, fit the apps to a focused purpose, capitalize on social interactions around the app, and provide scaffolding in order to support the development of early literacy skills. In addition, teachers should avoid relying solely on reviews of apps when selecting quality apps which best meet the needs of the students, and should instead evaluate the quality of apps based on the level of engagement, relevance, accuracy, and reinforcement within the app. Although the waters of digital media may be difficult to navigate, more research is available every day to help teachers understand how to guide children in practicing early literacy skills in meaningful ways through careful planning of which apps to use and how to best implement them in instruction.

Statement of Purpose

While early literacy apps are quite prevalent in early childhood classrooms, little research has addressed their effectiveness at appropriately engaging children while attempting to teach important skills. The purpose of this study was to obtain information about children's engagement with a small core of early literacy apps.

Research Questions

This study addressed the following research questions:

1. With respect to engagement and affect, what types of affective behaviors do children produce in response to three targeted early literacy apps?
2. To what extent did pairs of children vary in their responses to the different apps?

CHAPTER 2

Method

This is a descriptive study designed to explore the nature of children's engagement during their interactions with different apps and observe the extent to which their behaviors are related to the apps' features and task requirements. In addition to characterizing children's affect and engagement, a goal was to examine types of behaviors that pairs of children produced as they interacted with one another and with their teacher during encounters with the apps. Prior to conducting the study, the researchers obtained IRB approval and consent from the parents of the participants (See Appendix A for a copy of the consent form).

Targeted iPad Apps

The study drew upon three different iPad apps to help answer the research questions regarding child engagement. The apps were *Endless Reader*, *Hideout: Early Reading*, and *Preschool Matching Game: Rhyming Words*.

Endless Reader. The *Endless Reader* (ER) iPad app, developed by Originator Inc., (2014) was selected because it is a very popular app that has received positive reviews, including over 2,000 five-star ratings out of 2,573 ratings (iTunes App Store, 2016). It associates sounds with letters, blends sounds to make words, and associates written words with pictures and animated videos. It also presents spectacles (e.g., an animated character bowls over letters that then go flying off the screen), which probably contribute to its popularity. In fact, many of the positive reviews of the app point out that the app draws children in and maintains their attention with the entertaining spectacles. A high level of engagement in an app is generally important for effectively highlighting early literacy skills. However, despite the advantages of engaging interactions, ER has pedagogical flaws which detract from sound instruction of early literacy

skills. Some of the flaws include incorrect representation or association of letters and sounds, distortion of sounds when produced in isolation, and inaccurate blending of sounds into words. In addition, the app claims to be for ages five and under, but the activities focus on reading (i.e., blending letters and sounds to make printed words), and the targets used are first grade as well as kindergarten-level patterns.

Hideout: Early Reading. The *Hideout: Early Reading* (HO) iPad app, developed by faculty members at Brigham Young University (Third Rail Games LLC, 2014), was selected because it attempts to provide a theme-based context for introducing children to targeted rhyming words (e.g., words like *hop, shop, pop, top,* and *stop* are encountered while popping popcorn in a popcorn shop). The HO app provides children with frequent and explicit encounters with literacy targets in 'virtual' situations. It presents skills (target phonic and phonological patterns) with compelling game-like functions, navigational choice, and contingent interactions: *exploring* how objects interact and *creating spectacles* by making objects react in funny or unexpected ways. HO uses game mechanics to highlight a pattern in a virtual context (e.g., going to a pop shop to pop popcorn). Because much information about the task is built into the theme-based activity, the response expectations appear to be clear. The various activities include a) associating letters with sounds, b) creating words by blending onsets (initial consonant or cluster) with rime endings (the vowel and final consonant or cluster), c) using words within a word family to describe an experience, and d) presenting a text about the experience that highlights the targeted phonic pattern. While the app raises children's phonological sensitivity to rhyme patterns, relevant to preschool children, and focuses on reading short vowel targeted words, appropriate for kindergarten level, it does not explicitly teach rhyming to preschool children, relying instead only on incidental exposure to rhyme.

Preschool Matching Game: Rhyming Words. The *Preschool Matching Game: Rhyming Words* (PM) iPad app, developed by Alligator Apps (2014), was selected because it is typical of the rhyming apps available and uses colorful, attractive photos of real objects as the stimuli. The app arranges for children to tap on pictures of words to hear them named and then drag the pictures together of matching rhyming words. The task is simple and consistent, meaning that children are able to quickly and easily determine how to manipulate the app. While the photographs are attractive, they often represent obscure words, since apps rely on nouns that are imageable but not necessarily common. The inclusion of uncommon nouns results in vocabulary with which children cannot relate. Thus, children do not gain exposure to the rhyming skill within relevant contextual, salient experiences and language. The app permits children to slide words together but requires them to understand the rhyme-matching task without providing directions or demonstrations. In addition, it fails to provide adequate modeling or repetition of correct answers and allows users of the app to respond without gaining an understanding the rhyming principle involved.

Pilot Study

Some preliminary trials were conducted to develop procedures for observing children's use of the iPad apps. Attempts to define the procedures occurred in two ways. First, three pairs of children (six total children) between the ages of 4 and 8 were shown the three iPad apps, given the opportunity to manipulate the apps, and asked questions about what they liked and didn't like about the apps. The encounters were video recorded in order to observe the level of engagement and types of responses. It was noted that the children in these pairs freely conversed with each other about the apps they were manipulating.

Second, a more in-depth pilot study involved presenting eight children, ages 4 and 5,from Head Start classrooms with opportunities to explore the three targeted iPad apps on three separate occasions. On each occasion, a research assistant introduced the app, allowed pairs of children approximately 15 minutes to manipulate the app, and then interviewed them about what they liked or didn't like about the app. The pilot study was discontinued because, unlike in the previous pilot, the children failed to talk to each other about what they were experiencing. The researchers concluded that the lack of verbalizations may have been due to reticence associated with being in the presence of an unfamiliar adult outside of the classroom setting. Consequently, the subsequent study design involved utilizing a classroom teacher to conduct the small group sessions with the aim of capturing more verbalizations during interactions in a familiar, naturalistic setting.

Participants and Setting

Once pilot information was obtained, the decision was made to observe pairs of Head Start children as they interacted with the iPad apps. Thus, the participants for the actual study included 12 children age 4 to 5 who were enrolled in preschool classrooms at a Head Start program. The demographics of the participants included six children learning English as a second language (i.e., Child A in Pair 2, Child A in Pair 3, Child A in Pair 4, Child A and Child B in Pair 5, and Child A and Child B in Pair 6) as well as varying economic backgrounds. The children came from two teachers' half-day classrooms for a total of three participating classrooms. Although all children in the classes participated in the interactions with the apps, only students with parent permission were filmed and included in the study. The children's encounters with the apps took place in their own classroom with their teacher present to direct each session.

Procedures

The procedures of the study were conducted in two parts. First, the researchers oriented the teachers to the apps and then the teachers presented the apps to pairs of children across three sessions per pair.

Orienting the teachers. The teachers, who were present when the children encountered the apps, were first trained in the use of the apps and were allowed time to explore the apps on their own at home over a weekend. The teachers were also trained in how to facilitate the sessions and were given a protocol to follow throughout each session (See Appendix B for a copy of the protocol teachers used throughout the study). In addition, teachers received a randomized list of the order of presentation of the apps to each pair of children with a schedule to ensure that teachers rotated the presentation of apps and presented the apps at least one day apart.

Presenting the apps to children and providing time to explore. All of the 12 children experienced the three iPad apps in pairs with their classroom teacher present. Each session consisted of presenting one app to the children. Teachers followed a rotating schedule of to maintain balanced presentation of the apps and were required to wait at least one day before presenting the next app. Two cameras and a back-up audio recording device recorded the sessions. Prior to beginning each interaction with the app, the teacher introduced the app and provided a brief explanation of how to manipulate the app. Following this introduction the teacher placed the iPad in between the two children and allowed them 15 minutes to explore the app while sharing the iPad. Although children were allowed to independently negotiate turns and initiate actions, teachers facilitated sharing of the device through promptings related to turn-taking. During the time that the children were playing with the app, the teacher also responded

to questions and comments the children made and provided any assistance needed in manipulating the device.

Data Analysis

Data analysis consisted of transcribing the audio and video recordings of the interactions, including the verbal and nonverbal behaviors of the teacher and children throughout the interaction. The transcripts were then coded according to child and teacher behaviors. A total of 18 sessions were transcribed and coded, consisting of three transcripts for each of the six pairs of children. Following transcription and coding, analysis involved calculating descriptive statistics and characterizing behaviors across the three iPad apps and among pairs of children.

The transcription process. The video and audio recordings of the small group interactions were transcribed for verbal and nonverbal behavior. Transcriptions of verbal and nonverbal behaviors for the teacher and children in each small interaction captured the observations for data analysis.

Verbal transcriptions. The verbal portion of transcriptions captured all verbal comments and non-speech sounds uttered by the teacher and both of the children in the small groups throughout the entire interaction. Undergraduate students trained to perform verbal transcriptions used a key and met to compare transcriptions and ensure reliability between each transcriber. An independent research assistant reviewed the first three transcripts and compared them with the videos. The research assistant did not find any discrepancies between the videos and transcripts. Further observations throughout subsequent transcription and coding revealed only minimal errors in the transcripts, leading the researchers to find the verbal portion of the transcripts to be reliable.

Nonverbal transcriptions. Dr. Alex Rosborough, a Brigham Young University faculty member specializing in nonverbal behavior, trained and supervised undergraduate students tasked with adding nonverbal information to the verbal transcriptions. In order to ensure accuracy and reliability, Dr. Rosborough reviewed the transcripts and trained the students in using a key for notating gesture phrases, gesture strokes, silent pauses, rise in voice intonation, fall in intonation, and additional non-verbal related information. The nonverbal transcriptions were considered to be reliable except in the case of two transcripts which were less detailed due to equipment malfunction during the recording of the sessions. The rationale for including nonverbal information along with the verbal comments was to provide support for analyzing children's behaviors and intentions in communicating throughout the interactions with the apps.

The coding process. Following transcription of the verbal and nonverbal content of the children's sessions, research assistants coded the transcripts according to child engagement and interactions during use of the iPad. The research assistants included a graduate student and the mother of young child interested in early literacy apps.

Coding engagement and interactions during encounters with apps. The coding process began with creating categories to characterize child affective engagement, awareness of the targeted skill or content, focus in attending to the app, and peer interactions related to turn taking. The coders also established categories defining teacher behaviors. Affective involvement, classified as positive or negative affect, was determined by the presence of facial expressions and verbal statements. Awareness of the skill or content highlighted in a particular iPad app was determined by the following behaviors: commenting on the pattern, repeating the pattern or stimulus, generalizing the skill, and purposefully manipulating the game versus randomly tapping on the screen. Engaged focus was determined by observations of students

attending to the app while watching the screen. Categorization of teacher nonverbal and verbal behaviors consisted of coding prompts toward how to play the game, comments and questions about the game, and displays of affect. In addition to a priori categories of positive and negative affective engagement, the raters permitted themes, trends, or patterns to emerge from the data. See Appendix C for a copy of the coding key, including categories and definitions.

Determining reliability of coding. Two raters coded child and teacher behaviors exhibited during exploration of the apps. Determining reliability of raters' codings involved having two raters review the coding categories, independently code each transcript, then meet to determine agreement and resolve any disagreements. Average agreement between the raters for the first four transcripts was 54%. Due to the low percentage of agreement, the raters modified definitions of codes to increase inter-rater reliability. The average agreement between the raters for the next three transcripts was 71%, which led the raters to collapse categories on the coding key in order to simplify the codes and increase reliability. The average agreement for the following five transcripts remained at 71%, which led the raters to use a template for the remaining transcripts which included the number of codes per line. The average agreement for the final five transcripts was 80%. Disagreements throughout the process were resolved by analyzing the transcript and video and assigning the most applicable code based on mutual agreement by both raters. After coding the 18 transcripts the raters reviewed the early transcripts and made adjustments to reflect any changes to the coding key in order to ensure consistency across all of the transcripts.

Descriptive analysis. Following the coding of the verbal and nonverbal transcriptions, the coded responses were tallied and used to describe the way in which the children responded to each of the apps. The researchers calculated the means, standard deviations, totals, and

proportions of different types of positive and negative child behaviors. Researchers also characterized the behaviors children exhibited to determine whether or not common patterns existed within each of the apps and described variations in behaviors according to the different features and task requirements of the apps. Types of positive behaviors included positive affect, focused attention, and purposeful manipulation. Categories of negative behaviors included negative affect, inattention, and random manipulation. See Table 1 for descriptions of the coded positive and negative behaviors. In addition to exemplifying the manner in which children responded to each of the apps, the data were inspected to describe variations in the dynamics that occurred as children interacted with each other and with their teacher.

Table 1

Descriptions of Coded Positive and Negative Behaviors

Behaviors	Descriptions
	Positive Behaviors
Positive affect	Smiling, laughing, producing positive verbal statements and expressive sounds
Attention	Looking at the screen while manipulating the device, watching the screen while another child plays, leaning towards the game
Purposeful manipulation	Tapping pictures and words, dragging letters and words, manipulating characters and objects
	Negative Behaviors
Negative affect	Frowning, expressing frustration or hesitancy towards playing the game
Random manipulation	Rapidly and repeatedly tapping, incorrectly manipulating the game, haphazardly dragging pictures or objects
Inattention	Looking around the room, leaning away from the game, disengaging from the game

CHAPTER 3

Results

A descriptive analysis addressed two research questions related to types of child affect and engagement exhibited across the targeted apps and among the pairs of children. The analysis included calculating the means, standard deviations, totals, and proportions of different types of positive and negative child behaviors produced during encounters with the three apps. In addition, researchers also characterized the types of behaviors typically observed during children's interactions with each of the apps with regards to positive behaviors (positive affect, focused attention, and purposeful manipulation) and negative behaviors (negative affect, inattention, and random manipulation). The analysis also included descriptions of the dynamics that were observed as pairs of children interacted with each other, with the app, and with their teacher.

Analysis of Behaviors According to Each App

The first research question of the study, which related to child affect and engagement across the targeted apps, was addressed by describing the types of positive and negative behaviors children produced during encounters with each of the apps. Table 2 shows the child behaviors produced in response to the three apps, including the total behaviors, means, and standard deviations and Table 3 compares the proportion of positive and negative behaviors to total behaviors. Below is a description of numbers and types of behaviors observed for each app, including positive behaviors such as positive affect, focused attention, and purposeful manipulation and negative behaviors such as negative affect, inattention, and random manipulation.

Endless Reader app. Children who encountered the ER app produced a mean number of 17.7 behaviors related to positive affect, 13.7 of focused attention, and 30.0 of purposeful manipulation (Table 2). Examples of behaviors representing positive affect included making excited exclamations regarding the animations in the app, such as "Cake!" while the children viewed monsters eating cake and making relevant comments such as "I like Spaghetti!" while they viewed monsters eating spaghetti. Children also used expressive words such as "Silly!" while watching animated videos of monsters acting out the meaning of words. Other behaviors categorized as positive affect included smiling, laughing, and dancing along with the music in the ER app. Focused attention consisted of leaning forward towards the iPad and intently watching the screen, particularly during animated segments. Examples of purposeful manipulation included dragging individual letters to match letters in a word and dragging words to match words in a sentence.Descriptive statistics of child behaviors during encounters with ER showed a mean number of 2.3 behaviors related to negative affect, 2.8 of inattention, and 7.3 of random manipulation (Table 2). Some examples of behaviors representing negative affect included requests to play a different game and an instance where one child (Child A in Pair 3) covered her ears and said "It's too loud!" during a portion of the app where monsters knock down letters in a word. Inattentive behaviors consisted of pausing game play to look around the room and leaning away from the game. Random manipulation included behaviors such as haphazardly dragging letters around the screen and rapidly tapping on or around the content, particularly during instances when children were meant to passively view animated video segments rather than actively manipulate the app.

Table 2

Child Behaviors in Response to Three iPad Applications

	Total	Mean	SD
Positive Affect			
Endless Reader	106	17.7	8.5
Hideout: Early Reading	135	22.5	15.1
Preschool Matching Game: Rhyming Words	136	22.7	13.8
Focused Attention			
Endless Reader	82	13.7	5.2
Hideout: Early Reading	99	16.5	8.5
Preschool Matching Game: Rhyming Words	115	19.2	9.6
Purposeful Manipulation			
Endless Reader	180	30.0	12.5
Hideout: Early Reading	298	49.7	19.7
Preschool Matching Game: Rhyming Words	564	94.0	53.7
Negative Affect			
Endless Reader	14	2.3	3.8
Hideout: Early Reading	8	1.3	1.5
Preschool Matching Game: Rhyming Words	74	12.3	17.1
Inattention			
Endless Reader	17	2.8	1.8
Hideout: Early Reading	9	1.5	2.8
Preschool Matching Game: Rhyming Words	21	3.5	4.8
Random Manipulation			
Endless Reader	44	7.3	8.9
Hideout: Early Reading	113	18.8	13.5
Preschool Matching Game: Rhyming Words	128	21.3	18.0

Table 3

Total Behaviors and Proportion of Positive and Negative Behaviors in Response to Three iPad Applications

	Behaviors			Proportions	
	Positive	Negative	Total	Positive	Negative
Endless Reader	368	75	443	0.83	0.17
Hideout: Early Reading	532	130	662	0.80	0.20
Preschool Matching Game: Rhyming Words	815	223	1038	0.79	0.21

Children interacting with the ER app produced a total of 443 behaviors, the lowest total number as compared to the other two apps (Table 3), which may be due to intrinsic features of the apps. A lower number of total behaviors could be related to a segment of the ER app, in between the parts of the game focused on skills, where children watch animated monsters rather than actively manipulating the app. Although children generally appeared to like all aspects of the app, there was variability among individual children interacting with ER as evidenced by observations of some children who enjoyed repeating the same activities (e.g., Child A in Pair 1, Pair 4) while others grew bored during the allotted time period and wanted more options than the three activities offered in the free version of the app (e.g., Child B in Pair 1, Child B in Pair 2, Child A in Pair 3). Overall, children seemed to enjoy the ER app, as evidenced by a higher proportion of positive behaviors (83%) as compared to negative behaviors (17%) produced during encounters with the app (Table 3).

Hideout: Early Reader app. Descriptive statistics of child behaviors produced during encounters with HO showed a mean number of 22.5 behaviors related to positive affect, 16.5 behaviors for focused attention, and 7.3 behaviors representing random manipulation (Table 2). Examples of positive affect elicited during encounters with the HO app included laughter and excited exclamations about the content of the app such as “Kitty!” when children were tasked with getting a pet cat into a net and “Scrub-a-dub-dub!” while children scrubbed a cub in a tub. Children also produced exclamations of accomplishment like, “Yeah!” after successfully completing tasks such as dragging a hen to a pen or dragging a letter to make a word, which indicated positive affect toward the content of the app. Positive behaviors also included smiling and exhibiting awareness of the content or skill by imitating words, phrases, and sounds produced by the game. Behaviors representing focused attention consisted of looking at the

screen while manipulating the device or while intently watching another child take a turn in manipulating the device. Examples of purposeful manipulation included dragging letters to form words, manipulating objects in a contextualized activity, and tapping on words in a text.

Children who encountered the HO app produced a mean number of 2.3 behaviors related to negative affect, 2.8 behaviors of inattention, and 18.8 behaviors of random manipulation (Table 2). Negative affect included frustration at not being able to manipulate objects in the app, hesitancy to manipulate objects, and fidgeting behaviors. Inattention during encounters with HO consisted of looking at other children in the room, attempting to play with recording equipment, and momentarily disengaging to look around the room while the other child took a turn. Random manipulation included haphazardly tapping content in the game and randomly dragging objects around the screen.

Children produced a total number of 662 behaviors while interacting with the HO app, the second highest number of total behaviors for the three apps (Table 3), which may be due to the fact that all components of the app require some form of active manipulation. In the same vein, this aspect of the HO app may have also contributed to low numbers of inattention because children were required to actively participate during every segment of the app. Although some children struggled with correctly manipulating objects in certain activities in the HO app, most seemed to be able to purposefully manipulate the app without any trouble. Generally, children appeared to remain engaged throughout the segments of the app, including blending sounds to form words, manipulating objects representing the word family pattern, and activating an automatic reading of the text about the activity. As evidenced by a higher proportion of positive behaviors (80%) to negative behaviors (20%), children generally enjoyed the HO app.

Preschool Matching Game: Rhyming Words app. Descriptive statistics of child behaviors produced during encounters with PM showed a mean number of 22.7 behaviors related to positive affect, 19.2 behaviors of focused attention, and 94.0 behaviors representing random manipulation (Table 2). Some positive affective behaviors children produced during encounters with the PM app included imitations of the rhyming pairs in the app (i.e., "Ant and pant!") and excited comments about the photographs in the app (i.e., "That's a cute little dog!"). Children also imitated feedback provided by the app upon completion of a page of correct matching words (i.e., "Great job!"). Child behaviors of focused attention consisted of watching the screen while dragging pictures or while watching another child drag pictures. Examples of purposeful manipulation included tapping pictures to hear words named and dragging pictures to make successful rhyming matches.

During encounters with the PM app, children produced a mean number of 12.3 behaviors representing negative affect, 3.5 behaviors of inattention, and 21.3 behaviors of random manipulation. Negative affective behaviors children produced in response to the PM app included exclamations such as "Yuck!" and "Ugh!" in response to some pictures displayed on the screen. Children also expressed some confusion regarding obscure words and pictures, asking "What's that?" In addition, children tended to exhibit behaviors suggesting inattention and disinterest such as looking around the room, leaning away from the app, and resting face-down on the table, particularly toward the end of the encounter with the app. The most common negative behavior consisted of random manipulation of the app where children quickly and haphazardly drug pictures in attempts to make matches, which resulted in unsuccessful attempts or successful attempts without any apparent consideration of correct rhyming pairs. In addition, actions that the researchers initially coded as purposeful manipulation, according to information

in the transcript, looked random upon closer inspection of the video, where children were tapping pictures then quickly dragging to make matches without seeming to pause to consider the accuracy of the response.

The descriptive statistics also showed that children who encountered the PM app exhibited the highest mean number of behaviors for both purposeful and random manipulation (Table 2) and the highest total number of behaviors (Table 3), which may be related to the fact that the encounter requires children to either tap or drag pictures in attempts to make matches without pauses in the interaction for animations or videos. Variation among individual children encountering the PM app may have also impacted numbers of behaviors, particularly regarding focused attention. Some children appeared to enjoy the task of dragging photographs and exhibited high numbers of positive behaviors involving exclamations over the pictures or rhyming pairs (e.g., Pair 3, Child B in Pair 4). However, other children seemed to quickly bore with the repetitive nature of the task as evidenced by children who put their head down or exhibited frustrated gestures such as rubbing the face (e.g., Child A in Pair 5 and Child A and Child B in Pair 6). The encounters with the PM app also showed higher levels of teacher prompting towards how to play the game, specifically in the form of reminders to tap the pictures in order to listen to the word and consider correct rhyming pairs. Children who interacted with the PM app exhibited a higher proportion of positive behaviors (79%) as compared to negative behaviors (21%), indicating that overall children enjoyed the encounter with the app.

Analysis of Behaviors According to Pairs of Children

The second research question of the study, which examined variations in child behavior among pairs of children was addressed by comparing the descriptive statistics across pairs and by describing the behaviors that the pairs of children exhibited as they interacted with each other,

with the app, and with their teacher. Table 4 shows the numbers of behaviors that pairs of children engaged in during encounters with the apps, including totals, means, and standard deviations of behaviors for each pair. The analysis also considered the dynamics of peer and teacher interactions, including teacher behaviors directed toward prompting and support and child behaviors indicating sharing or dominating the device. Table 5 shows the numbers of child turn-taking behaviors in the form of dominating the device and sharing the device as well as teacher behaviors related to prompts, support, and displays of affect as children interacted with the apps.

Positive and negative child behaviors. Examination of the types of behaviors children exhibited in response to the apps revealed variations among pairs of children. For example, Pair 6 displayed the highest mean for positive affect (i.e., children smiling and laughing with one another and with the teacher over game content) as well as the highest mean for negative affect (i.e., displays of behaviors associated with hesitancy or frustration in playing the game) during encounters with the apps (Table 4). Pair 5 had the highest mean number of behaviors related to both focused attention (i.e., intently watching the screen while another child plays) and inattention (i.e., looking around the classroom) throughout interactions with the apps (Table 4).

In addition to variation across pairs of children, the researchers also noted differences in types of behaviors among individual children. Some children manipulating the apps seemed to exhibit more exaggerated positive and negative behaviors than others. For example, Child B in Pair 4 excitedly named rhyming pairs throughout the PM and HO apps and Child A in Pair 5 used animated gestures to celebrate successful attempts at tasks in all three apps. In contrast, Child B in Pair 5 often exhibited negative behaviors such as looking away from the device and leaning on the table, particularly following instances in which Child A dominated the device. As

a result, overall pair variations in behaviors representing affect and engagement were influenced to a degree by individual children exhibiting extremes in behaviors.

Dynamics of peer and teacher interaction. Variations in child behaviors also occurred relative to the dynamics of peer and teacher interaction, specifically in the number of teacher prompts and the numbers of behaviors related to child turn-taking. Pair 1, 2, and 5 tended to display higher instances of one child dominating the device as well as higher instances of teacher prompts towards turn-taking, while Pair 3, 4, and 6 tended to display a greater number of instances where the children shared the device (see Table 5). For example, Child B in Pair 2 repeatedly used a raised tone of voice in claiming a turn and frequently pushed Child A's hand out of the way, while Child A and Child B in Pair 4 often willingly yielded a turn to one another. Overall, the pairs of children who were better able to share the device seemed to have a more positive experience with the apps than those pairs who did not, however, the differences in behaviors related to turn-taking appeared to relate more to the personalities of the individual children in the pairs rather than to particular features of the apps. Besides variations in pair dynamics with respect to child turn-taking behaviors, the researchers also noted differences in pair dynamics related to levels of teacher prompts, supports, and displays of affect. For example, Pair 1, 2, and 3 had relatively high levels of teacher behaviors (i.e., prompting toward how to play the game, commenting on the game, laughing with the children, controlling turn-taking) while Pair 4, 5, and 6 had relatively low levels (Table 5). Evidence of variations in the numbers of child behaviors related to turn-taking behaviors and teacher behaviors directed toward prompts and support suggests that the different dynamics involved in child interactions with a peer and the teacher could have influenced the level of affect and engagement displayed by pairs of children.

Table 4

Child Behaviors in Response to Three iPad Applications According to Pairs of Children

	Endless Reader	Hideout	Preschool Rhyme	Total	Mean	SD
			Positive Affect			
Pair 1	6	21	8	35	11.7	8.1
Pair 2	15	8	9	32	10.7	3.8
Pair 3	17	26	36	79	26.3	9.5
Pair 4	27	8	14	49	16.3	9.7
Pair 5	28	23	37	88	29.3	7.1
Pair 6	13	49	32	94	31.3	18.0
			Focused Attention			
Pair 1	13	20	5	38	12.7	7.5
Pair 2	7	7	13	27	9.0	3.5
Pair 3	17	13	25	55	18.3	6.1
Pair 4	18	20	25	63	21.0	3.6
Pair 5	19	30	31	80	26.7	6.7
Pair 6	8	9	16	33	11.0	4.4
			Purposeful Manipulation			
Pair 1	22	36	66	124	41.3	22.5
Pair 2	20	36	73	129	43.0	27.2
Pair 3	52	39	159	250	83.3	65.9
Pair 4	21	37	17	75	25.0	10.6
Pair 5	37	77	149	263	87.7	56.8
Pair 6	28	73	100	201	67.0	36.4
			Negative Affect			
Pair 1	1	2	1	4	1.3	0.6
Pair 2	2	0	1	3	1.0	1.0
Pair 3	10	0	4	14	4.7	5.0
Pair 4	0	0	4	4	1.3	2.3
Pair 5	1	3	20	24	8.0	10.4
Pair 6	0	3	44	47	15.7	24.6
			Inattention			
Pair 1	0	0	0	0	0.0	0.0
Pair 2	4	2	0	6	2.0	2.0
Pair 3	2	0	1	3	1.0	1.0
Pair 4	2	0	1	3	1.0	1.0
Pair 5	5	7	11	23	7.7	3.1
Pair 6	4	0	8	12	4.0	4.0
			Random Manipulation			
Pair 1	3	11	24	38	12.7	10.6
Pair 2	2	24	10	36	12.0	11.1
Pair 3	24	3	55	82	27.3	26.2
Pair 4	11	11	20	42	14.0	5.2
Pair 5	3	41	15	59	19.7	19.4
Pair 6	1	23	4	28	9.3	11.9

Table 5

Teacher and Child Behaviors Exhibited During Encounters with Three iPad Applications Displayed According to Pairs of Children

	Endless Reader	Hideout	Preschool Rhyme	Total	Mean	SD
Teacher Prompts, Support, and Displays of Affect						
Pair 1	37	110	68	215	71.7	36.6
Pair 2	69	95	59	223	74.3	18.6
Pair 3	68	54	109	231	77.0	28.6
Pair 4	30	45	39	114	38.0	7.5
Pair 5	30	60	66	156	52.0	19.3
Pair 6	24	51	72	147	49.0	24.1
Child Behaviors Related to Dominating the Device						
Pair 1	13	6	6	25	8.3	4.0
Pair 2	7	14	19	40	13.3	6.0
Pair 3	11	2	0	13	4.3	5.9
Pair 4	3	2	4	9	3.0	1.0
Pair 5	6	9	63	78	26.0	32.1
Pair 6	3	1	8	12	4.0	3.6
Child Behaviors Related to Sharing the Device						
Pair 1	4	5	20	29	9.7	9.0
Pair 2	10	20	9	39	13.0	6.1
Pair 3	15	15	18	48	16.0	1.7
Pair 4	15	8	9	32	10.7	3.8
Pair 5	7	25	30	62	20.7	12.1
Pair 6	6	19	21	46	15.3	8.1

Summary

In summary, the types of child behaviors produced throughout encounters with the apps varied according to specific features of the apps. A lower number of total behaviors for the ER app may be attributed to segments of the app where children were passively watching a video rather than actively manipulating the app. Lower numbers of inattention for the HO app could be attributed to the fact that children are required to actively participate in every segment of the app. Higher numbers of both random and purposeful manipulation for the PM app may be

attributed to the fact that the encounter requires children to either tap pictures or drag pictures in an attempt to make a match without pauses in the interaction for animations or videos.

Variations in behavior also depended on the dynamic of the pair involved in the interaction, with some pairs exhibiting higher instances of fighting over control of the app while others willingly shared the device, leading to a more pleasant experience during the interaction. Individual children also displayed different types of positive and negative behaviors during encounters with the apps, which resulted in variances in the way the pairs of children responded to the apps.

CHAPTER 4

Discussion

The purpose of this study was to gain information about the nature of children's engagement with three targeted early literacy apps. A descriptive analysis of the data revealed that although all three apps had relatively equal proportions of positive and negative child behaviors, the types or patterns of behaviors differed. It appears as if the types of behaviors were influenced by the inherent design features of each of the apps. In addition to the patterns of behavior being linked to differences among apps, some differences in interactions between children within the various pairs was noted. Some pairs displayed more equitable access between both children to the app; whereas, other pairs had a child that dominated the app or two children who fought over control of the app. A discussion of the results includes interpretation of findings, limitations of the study, implications for future research, and implications for practitioners.

Interpretations of Findings

Analysis of the data found answers to two main research questions. The first question was answered with a descriptive analysis which revealed that the types and degree of behaviors children exhibited varied according to the features and requirements of each app. The second research question was also answered with a descriptive analysis which showed that variations in the interactions occurred among pairs of children.

Analysis of child affect and engagement according to app. The three apps were relatively equal in terms of the proportions of positive and negative behaviors children produced, and children exhibited more positive than negative behaviors overall or for each app. Analysis of the child behaviors according to app indicated that many of the variations in the specific types

of positive and negative behaviors were a reflection of differences in the nature of the apps. For example, a lower number of total behaviors for the ER app may be related to segments of the app where children were passively watching a video rather than actively manipulating the app. Higher numbers of both random and purposeful manipulation for the PM app may be attributed to the fact that the app requires children to either tap or drag pictures in attempts to make matches without involving video or animated segments like the other apps. Lower numbers of inattention for the HO app could be attributed to the fact that children were required to actively participate in every segment of the app. In addition, children who interacted with ER and HO danced along to the music and laughed at animated videos of monsters or moving objects, while children who manipulated the PM app commented on the interesting photographs.

During encounters with ER and HO, children appeared to exhibit purposeful manipulation in the form of moving letters and objects to a specific location in order to elicit animated responses from the app. In contrast, manipulation of the PM app consisted mostly of children dragging photographs quickly and haphazardly in attempts to make matches. While the PM app had the highest mean number of purposeful manipulation, as represented by the coding of the data, closer examinations revealed that in some cases the matching behaviors were, in fact, more random than purposeful when viewed in light of the specific demands and requirements of the app. At times the subtle distinction between rapid trial and error tapping and knowledge based responding was difficult for the coders to discern with accuracy, leaving the researchers to infer intent based on nonverbal behaviors in the context of each app. As such, analysis indicated that child behaviors were influenced by the features of the apps.

Analysis of child affect and engagement according to pairs of children. A comparison of behaviors exhibited across pairs of children revealed differences in behaviors

children exhibited during encounters with the apps. Variations in the frequency and types of behaviors children displayed may have been influenced by dynamics stemming from interactions with a peer and teacher. Pairs of children differed in the level of affect and engagement displayed, as evidenced by some pairs who laughed together and appeared to enjoy particular apps while other pairs exhibited inattention and looked away from the same app. Differences in the levels of positive and negative behaviors displayed by pairs of children may have been influenced by one of the children in the pair (i.e., children confident in rhyming appeared to enjoy rhyming activities whereas children who appeared not to understand a targeted skill seemed inattentive) or by the dynamics that arose between children in the pairings (i.e., pairs of children who were observed to frequently fight over the device versus pairs who willingly shared).

In addition to the interactions between pairs of children, variations in teacher prompts and support may have also contributed to the level of affect and engagement displayed by children interacting with the app and with each other. In particular, the encounters with the PM app showed higher levels of teacher prompting related to their giving explanations with respect to how to play the game. These explanations occurred specifically in the form of reminders to tap the pictures in order to listen to the word and consider accuracy of rhyming pairs when making a match. According to Trawick-Smith and Dziurgot (2011), teachers must use caution in scaffolding child play interactions so as to provide adequate support without providing so much support that teacher prompting inhibits independent child engagement. Variations in the levels of teacher support, according to app and pairs of children in the current study, may have impacted child responses during encounters with the apps. The need for teacher direction most

likely indicates that the demands of the PM task itself was most likely too difficult for the children.

Limitations

This study has limitations in its scope due to the design which is not generalizable beyond the current participants. The study was also limited in factors which influenced the data, including the demographics of the participants and the environment involved in the data collection phase of the study.

Participants. The use of a descriptive rather than experimental design, the demographics of the participants involved, and the small sample size all led to limitations in the application of the findings. The descriptive nature of the study resulted in valuable information, however, the results cannot be applied beyond the participants of the study as is possible with studies involving experimental design. In addition, the participants included children from low-income families, which may have influenced children's prior exposure to early literacy apps in general as well as individual responses to the three targeted apps. The demographics of the participants also included children who were learning English as a second language. Although teachers judged all of the children as having sufficient language to participate, the fact that some children were learning English as a second language participant demographics may have contributed to differences in level of communication with a partner in a pair due to variations in the dynamics of pairs caused by limited communication in English. With respect to sample size, although the researchers attempted to draw from a large sample size, parent refusal to participate, and difficulties of maintaining consistency across pairs of children given absences, led to a small sample size. The small sample size in combination with the participant demographics and descriptive design of the study limits generalizability of the results.

Environment. In addition to limitations related to participants, the study was also limited due to unforeseen and uncontrollable elements of the environment of the data collection phase. In an effort to help children feel comfortable, and thereby increase the level of peer-to-peer and peer-to-adult interaction, the researchers conducted the study in the children's own classrooms. Preschool classrooms, however, are full of noise and distractions which are not conducive to data collection. In addition, despite efforts to create back-up systems, some of the sessions were not fully recorded due to malfunctioning equipment. This led to inadequacies in the video recording, and ultimately transcriptions, which caused difficulties in coding the data.

Implications for Future Research

The descriptions of child behaviors relating to affect and engagement throughout encounters with three targeted early literacy apps in the current study provide valuable information for future researchers. Based on the results of the current study, future researchers should consider ensuring reliability of nonverbal coding, more tightly structuring the testing environment, and examining features and flaws of apps.

Ensuring reliability of nonverbal coding. The nature and complexity of analyzing child behaviors in the current study led to difficulty in obtaining consistency in transcriptions and coding, which led to issues with the validity of the data. Even though the researchers took care to ensure reliability among the transcripts through guidelines and training, in retrospect, the researchers discovered that when new assistants looked at the transcripts for analysis, they found some discrepancies, which may be due in large part to the challenges of describing complex behaviors. The coding of complex behaviors was subjective and varied according to the app, meaning it was difficult to obtain a high level of agreement. For example, the definition of purposeful manipulation varied by nature of app in that the PM app required high levels of

tapping and dragging as opposed to the ER app which had periods of passive participation while children viewed animation and the HO app which required low, but steady levels of manipulation throughout the entire interaction. Future researchers will need to consider the complexities of assigning codes to nonverbal behaviors and plan carefully in order to ensure reliability to of the coding.

Structuring the environment. Given the complexities of collecting and analyzing data related to child behaviors of affect and engagement, future researchers may consider tightly structuring the testing environment in order to eliminate some of the variables which created additional complexity in the current study. An element which increased the complexity of the environment of the current study was the collection of data involving pairs of children in a classroom setting. Although the descriptions gathered in the analysis of the data for this study were valuable for understanding the types of behaviors children exhibit during encounters with apps, additional quantitative studies may need to control for confounding variables such as the dynamics between peers and the adult facilitating the interaction. Future researchers may consider conducting the data collection with children individually instead of in pairs to eliminate difficulties that may arise when the dynamics of small groups of children are such that children begin fighting over the device. On the other hand, as the researchers of this study discovered during the pilot study, interactions among pairs of children in a naturalistic setting lead to more verbalizations than occurred in more controlled settings, indicating that future studies may find valuable information in conducting further quantitative research with small groups of children in authentic settings.

Examining features and flaws of apps. In addition to carefully ensuring reliability of coding nonverbal behavior and structuring the environment, future researchers may also consider

examining features and flaws of early literacy apps. The varying components of the three targeted apps in this study led to variations in the types of behaviors observed, indicating that future researchers may need to compare similar elements of apps such as viewing videos, playing games, interacting with texts, and manipulating objects. Comparison of behaviors produced during specific segments of similar apps will allow researchers to determine which aspects of an app contribute to engagement and learning.

The researchers of this study also noted potential flaws in the targeted apps (i.e., pedagogical errors in ER, use of obscure words in PM, and incidental exposure to rhyme rather than implicit instruction of the targeted skill in HO) as well as limitations in discerning whether or not children are actually learning early literacy skills. The researchers found that it was difficult to tell whether children were engaged on a skill level or solely with the content, implying that what may appear as engagement on the surface may not reflect what the children are actually learning throughout interactions with the apps. Even if children were focused and exhibiting positive affect, in some cases these observable behaviors most likely did not relate to what children learned, which is notable given that many parents and teachers choose early literacy apps for the purpose of teaching children skills. Although the focus of this study was on engagement and affect rather than what children learned from the apps, future studies may learn from the descriptions of child interactions with three different types of apps in order to choose a wider variety of apps and gather information about the possible strengths and weakness of particular apps in contributing to what a child understands about early literacy skills.

Implications for Parents and Teachers

In addition to allowing future researchers to plan for more controlled studies, the descriptive information of this study could benefit parents and teachers in that descriptions of

child behaviors exhibited while manipulating the three targeted apps can help in developing guidelines for choosing quality apps. For example, the discrepancies between data showing behaviors that appeared on the surface as purposeful manipulation, but were actually closer to random manipulation upon closer inspection, may help adults to see that what may appear to be child engagement on the surface may not be true engagement. As a result, adults will need to use caution in choosing apps because apps which appear to be engaging and beneficial in teaching a child early literacy skills, may not provide the level of engagement necessary for children to gain new skills.

Parents and teachers may also benefit from the data describing teacher supports and prompting in order to determine how to best facilitate child engagement with other early literacy apps. While the dynamics of peer interactions complicated data collection and analysis, the descriptions of how the children interacted with one another and with their teacher are valuable in understanding how to facilitate small group encounters with an app. Parents and teachers may need to consider procedures for managing turn-taking while small groups of children share a device or how to increase levels of interaction and socialization in a one-on-one setting with an adult and child.

Summary and Conclusions

The purpose of the study was to obtain information about children's engagement with the ER, HO, and PM apps early literacy apps. Children exhibited relatively equal proportions of positive and negative behaviors in response to the three apps, however, types of behaviors varied across apps and among pairs of children. A descriptive analysis of the data, including characterizations and descriptions of child behaviors, revealed information which was not captured by calculations of coded behaviors alone. Upon closer examination, behaviors that

seemed to represent purposeful manipulation, based on coded transcripts, did not necessarily reflect children's actual levels of focused attention to the skill being exemplified, especially when aligned with the demands and requirements of each of the apps. This indicates that practitioners should be aware of the features of individual apps and consider that what may look like child engagement on the surface may be an interest in the catchy elements that aren't related to modelled learning opportunities or may simply reflect high levels of random button pushing. Although the researchers of this study did not examine child learning related to apps, the descriptions of child behaviors related to engagement suggest that practitioners and future researchers should consider which features of apps elicit engagement leading to meaningful experiences in developing early literacy skills.

Furthermore, positive and negative child behaviors were influenced by the dynamics that occurred as the children interacted with one another, and with their teacher. Some pairs exhibited higher instances of fighting over control of the app while others willingly shared the device, leading to a more pleasant experience during the interaction. The variations in behaviors related to fighting over or sharing the device appeared to relate more to the personalities of the individual children in the pairs rather than to particular features of the apps. Individual children also displayed different degrees of positive and negative reactions to the apps and to interactions with their peer while using the apps, which resulted in slight variances in the way the pairs of children responded to the apps. Overall, the variations of behaviors according to pairs of children did not negate the patterns of behavior linked to the features of the apps, as the variations appeared to relate more to the personalities of the children in each pair than to the apps themselves.

The types of positive and negative behaviors children displayed depended on the features of the app and the pairing of children, indicating that parents and teachers hoping to use early literacy apps will have to carefully choose the types of apps and the ways in which they use the apps in order to ensure that children remain engaged. Practitioners will need to observe the nature of positive behaviors children exhibit during encounters with apps in order to ensure that these behaviors reflect engagement with the targeted skills and not merely with the spectacles that can be created by interacting with the app. In terms of affect and engagement, the descriptions gathered from the data provide valuable insight into ways in which children may respond to early literacy apps.

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APPENDIX A CONSENT FORM

Children's Engagement with Interactive iPad Apps to Teach Early Literacy Skills
Consent to be a Research Subject

Introduction
This research study is designed to determine children's interest in and interactions with iPad applications designed to support the development of early literacy skills. The study is being conducted by Kendra Hall-Kenyon and Barbara Culatta, faculty with expertise in early literacy instruction, with assistance from students at Brigham Young University. The iPad apps have been created to engage children and to give them control over delivery of the content, and to exposure them to sound and reading patterns.

Procedures
Your child will interact with three iPad activities over 1 or 2 sessions. Each session will last approximately 20 to 30 minutes and will include acting on early literacy activities presented on an iPad. The iPad sessions will be video recorded and watched by the researchers to determine how your child responds to and acts on the digital material. With your permission, small segments of the clips will be isolated to illustrate children's engagement during the instructional activities.

After engaging with the iPad app, your child will be asked to rhyme with the targeted sound pattern, read 1 or 2 of the words emphasized in the iPad activity, and tell whether or not the activity was enjoyable. Video recordings of these tasks will not be used for future purposes and will be destroyed following data collection.

Confidentiality
To protect confidentiality, all information and videotapes will be kept confidential and will be stored in a locked office. No names will be used to report results. Identifying information (names, locations) will be changed. The video will be viewed and edited by the investigators to identify examples of children's engagement and, with your permission, some segments will be kept for teacher training purposes.

Risks/Discomforts
There are minimal risks associated with the program. Your child may become highly focused on the iPad, may not want to switch tasks, or may not be interested in a particular activity. However, all participants will be told that they do not have to participate in the activities.

Benefits
There are no direct benefits for your child's participation in this project. Other children, however, have been observed to enjoy the instructional activities. The information gained will also be useful in determining how digital instructional materials should be incorporated into early childhood classrooms.

Questions about the Research
If you have any questions regarding the research project, you may contact Dr. Barbara Culatta at (801) 422-6456 or barbara_culatta@byu.edu.

If you have additional questions or concerns regarding your child's rights as a research participant, you may contact BYU IRB Administrator at A-285 ASB, Brigham Young University, Provo, UT 84602. Or you may call at (801) 422-1461 or send emails to irb@byu.edu.

Consent to Participate in the Study
Participation in this research study is voluntary. You have the right to withdraw your child at any time or refuse to allow him/her to participate without any consequence.

If you willingly agree to permit your child to particulate, please sign the consent form and return it to your child's teacher.

Signature:_____Date:_____

Consent to Show the Video
With your permission, video recordings of the children interacting with the instructional iPad applications may be used for future training and professional development purposes.

Please indicate what uses of these videotapes you are willing to permit by putting your initials next to the uses you agree to and signing below. This choice is completely up to you. We will only use the videotapes in ways that you agree to. In any use of the recordings, your child will not be identified by name.

_____ The videos can be shown at scientific conferences and to students in classrooms.

_____ The videotapes can be posted to a web site.

I have read the above descriptions and give my consent for the use of the videotapes as indicated by my initials above.

Parent's Name_____

Parent's Signature_____

Date _____

APPENDIX B TEACHER PROTOCOLS

Each session should last 5-10 min. If the child is still playing the game after 12-13min, give them a 2 min warning and begin the post-activity probes at 15 min.

Allow the children to guide the experience as much as possible. Use the probes sparingly and only when necessary. Be responsive to the children's expressed emotions and questions.

Introduction to game:
Say: *Here's a game we are going to play together. For now we can only play this game, later we will play another game. We want to know what you think of this game.*

Go to the first page where there are options and let them play the game. Point to the screen and say, "*Here is the game for you to play."*

> *Note:* For the preschool matching game, you have to touch the pictures to hear the names of the items. So say to the child, "For this game we have to touch all of the pictures on each new page before we start playing. Here is the first page. Touch all of the pictures before you start to move any of the pictures.

It is anticipated that most children will just begin playing the game and you will observe with periodic comments or responses to what the child says. It should be as naturalistic as possible. Take on the emotion that the child is exhibiting. Look at the iPad – lean in and be interested. Much of your communication will be non-verbal with an occasional comment, but let the child lead.

If the child ***doesn't know how to play*** the game:

> Show them how to use it one small step at a time (not too much support). We don't want them to be stuck but want to see what they can do on their own.
>
> For example: If child doesn't know how to drag pictures in Preschool Matching Game you might say, "Oh look, you can drag this picture" and then just drag the picture part way across the screen. You do not want to match up the cards unless it is obvious that the child doesn't know what they are supposed to do.
>
> When necessary – give simple direction: "move the picture to the one that sounds the same" or "move the net to get the pet" or "drag this letter to make the word"
>
> Try to make this as naturalistic as possible – engage with the child and help them to know what to do if they are stuck but do not make this an "instructional session."

If child is ***off task or distracted*** during the play session you might say,

"oh look at what this does and drag or move something"

"What else can this game do? " Can you make it do anything else?"

If child ***doesn't say anything*** throughout the game you should ask a few questions to prompt some conversation. Be careful not to use these too much. The children should guide the conversation:

What do you think of this game?

What does this (point to something on the screen) do?

Occasional praise. Mostly you will give non-verbal feedback with a smile back or a surprised look back—mimic child's emotion. Be careful not to use too much verbal praise. These comments should primarily be in response to children's comments.

Wow!

You know how to make this work!

Oh, look at that!

Avoid saying "good job"

Be sure that feedback is natural and consistent across apps.

If child says it is ***boring or doesn't want to do it anymore***. You might something like:

Try a few more

Comment on the target words – "Oh – lamb/tram those go together"

If these don't work, use this as a ***last resort***:

Look at what this does (demonstrate) now you take a turn

At this point, if you really think they won't keep playing without your help then just see what it takes to keep them involved. You only want to do this if you think they are really done and you have tried everything else.

APPENDIX C CODING KEY

AEC	**Child Affective Engagement**
P	***Positive affect***
1	Facial expressions or actions (smiles, laughs, leaning forward towards the game, looking toward the teacher or a peer for validation)
2	Verbal statements (I like this app, I want to play that one, comments about the game said excitedly when the statement includes more than one word)
3	Expressive words or sounds (wow, silly, yeah, one word comments about the game transcribed with an exclamation point – i.e. cake! Expressively naming a single picture from the game)
4	Positive affect unrelated to the game; affect in response to teacher/peer statements or actions (e.g., excitement another yielding a turn;
N	***Negative affect***
1	Facial expression or actions (frowns, covering ears, leaning away from the game, body language suggesting disinterest such as head down leaning on hand, frustrated gestures such as rubbing face or fidgeting with clothing, hesitancy in playing game)
2	Verbal statements (it's too loud, request to play different game)
3	Expressive words or sounds (Ugh! Uck!)
4	Negative affect unrelated to the game; affect in response to teacher/peer statements or actions (e.g., excitement another yielding a turn;
O	***Neutral affect***
1	Facial expressions or actions (touching face, pushing hair out of face)
AC	**Child Awareness of the Content/Context (spectacle) and Targeted Skill**
1	Commenting on the content or skill (relevant verbal statement related to game (child initiated and not in response to teacher question/prompt) such as "I like cake" or "Cake!" in reference to a picture of cake); generalizing the skill (e.g., producing *dot* to rhyme with *pot* when *dot* was not mentioned in the game).
2	Response to teacher/peer question/prompt (verbal statement, action, or command in response to teacher and/or peer – not child initiated/spontaneous)
3	Repeating content/context/spectacle or repeating the pattern or stimulus (imitating)
4	Question about the game (related to content, game function, skill, etc.)
5	Purposefully manipulating the game (tapping a monster to initiate animation; moving hens to a pen; children touching screen, dragging a letter, tapping on a button to read text, dragging to make rhyme match, reference to "playing" the game, pointing to relevant content, unsuccessful attempts due solely to ipad malfunction, one child pointing at something specific to help the other child)
6	Randomly manipulating the game (rapidly/repeatedly pressing buttons, producing a lot of errors; incorrectly manipulating game – tapping in the wrong spot; unsuccessful attempts (unless it is an ipad malfunction); accidently closing the game; guessing (as evidenced by frequent teacher prompts)
7	Focused attention (behaviors describing looking at screen, watching, smiling at the iPad etc.)
8	Inattention (behaviors describing looking around the room, at other kids, etc.)
9	Tangential or irrelevant comments

PI	Child Interactions with a Peer/Teacher Related to Turn Taking
1	Claiming a turn (reaching without touching yet; hovering over the screen while watching animation);
2	Willingly giving other child a turn (offering a turn, turning it over when child asks, sharing the device, waiting while another child takes a turn, references to both children playing)
3	Pushing the peer out of the way (physical contact – pushing, moving hand away, etc.);
4	Dominating the device (one child took more turns, one child reaches over another, verbal refusal of another child's claiming of a turn; two children fighting or competing over the device)
5	Gives other child a turn in response to teacher prompting
TP	**Teacher Prompts/Questions/behavior**
1	Prompting toward how to play the game; Asking questions about the game; Commenting on child statements or actions
2	Controlling or supporting turn taking (words and actions, including comments such as "Thank you" following children taking turns)
3	Positive teacher affect in regard to iPad (dancing, laughing, positive comments, smiling); positive reinforcement from the game or from the teacher (great job!)
4	Negative affect