Positive Technological Development for Young Children in the Context of Children's Mobile Apps

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Abstract

This dissertation examines the extent to which children's tablet software applications, commonly called *apps,* are designed appropriately to promote the optimal development of preschool children aged three to five. This study extends previous research, particularly the theoretical frameworks of *developmentally appropriate practice* and Bers' *positive technological development.* The researcher argues that, for children's mobile apps to be developmentally meaningful, they need to satisfy three conditions: (1) apps must be designed appropriately to accommodate the developmental stages and needs of young children; (2) content must be designed to promote young children's development in the areas of cognition, academic skills, social-emotional skills, and physical development; and (3) digital interactions engage children in activities and behaviors that foster optimal developmental assets. The researcher devised three instruments to evaluate and examine the breadth, depth, and design quality of 100 children's apps from the Apple's App Store for iPad. Content analysis revealed that only a non-significant majority of apps (58%) were meaningfully designed for preschool children in terms of user interface, audio and visual design, and instructional support. The apps selected for this sample included games and learning activities, interactive eBooks, as well as creativity and utility apps. The content of these apps tended to cluster around school skills and they rarely engaged children in activities beyond academic drill-and-practice. These apps largely ignored the social, emotional, and physical aspects of children's development. Using numerous vignettes and examples as illustrations, the analysis highlights design techniques, content offering, and technological features that could be productive toward children's development, as well as those that distract from meaningful user experiences. This study underscores the need for developmentally meaningful children's mobile apps for preschool children.

Dedication

This dissertation is dedicated to my mother and her four sisters

who showed me the meaning of the proverb,

"It takes a village to raise a child."

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4 year-old Oliver picks up an iPad Mini and turns it on with ease immediately. Eyes fixated on the device in front of him, he presses his index finger to the screen and swiftly swipes across the tablet. He notices the icon of his favorite game and quickly taps on it to start playing.

Oliver tells the researcher, “I have Toca Cars at home too!”

The researcher asks, “Do you play this with your mom?”

Oliver replies, “No, I know how to play this by myself.”

1.1 Introduction

The introduction of touch-based, mobile tablet computing gave birth to a world of applications for all sorts of purposes from entertainment applications such as video and music players to productivity tools including word processing, web-logging (i.e. blogs), and financial software. Since the inception of the Apple's App Store on July 10, 2008, the apps industry has seen a rapid and explosive growth, with over one million apps as of December 2013 (148apps.biz), within which approximately 10% or 107,000 are advertised as educational or intended for children 11 and under. Apple saw over 50 billion app downloads in the five years since the first app was sold (9to5mac.com). An average of 10 billion business transactions per year speaks to the import of this industry.

As with any other consumer electronic products, the tablet computing industry soon saw a burgeoning demand for child-friendly content, especially for preschool aged children as parents look for novel and appropriate ways to occupy their children's time and attention throughout the day (Nielsen, 2012). Within a matter of a few years after the introduction of Apple's popular iPad tablet, mobile tablet software, commonly referred to as "apps," has rapidly grown in popularity and has become a much-debated issue in the education and child-development spheres.

While educators, advocacy groups, and practitioners continue to debate children's consumption of tablet and screen-based media content, Apple's march toward expanding the children's content market has only quickened over time. On September 18, 2013, Apple launched the "Kids" category of the Apple's App Store and app producers can now assign a target age range to their child-oriented apps (i.e., 5 years and under, 6 years to 8 years, and 9 years to 11 years) to streamline content discovery on Apple's virtual marketplace. Apple provides little information or guidance on appropriate design and content guidelines for apps targeting children in these age categories, and these apps undergo minimal content curation and appraisal aside from a superficial review to ensure their adherence to legal requirements such as protecting children's privacy and prohibiting in-app financial transactions (Apple Inc., 2014). The outcome of this new category has given app creators a direct and somewhat unregulated channel to reach the child audience.

This recent surge in the popularity of children's mobile apps raises many questions among practitioners and educators as to their potential impact, both positive and negative, on the overall development of young children. As an example, the National Association for the Education of Young Children (NAEYC) released a joint statement with the Fred Rogers Center in 2012 acknowledging the omnipresence of screen-based media technology in today's society, and recognized that, "When used intentionally and appropriately, technology and interactive media are effective tools to support learning and development" for preschool children (NAEYC, 2012a, p.1). Yet at the same time, this potential is not uncontested. NAEYC (2012b) also raised questions about the impact of technology and interactive media on young children's lives, noting that there is "conflicting evidence on the value of technology in children's development" (NAEYC, 2012b, p.2). In particular, mobile apps targeting preschool children aged three to five have recently taken a spotlight at the center stage of this debate.

The AAP asserts (2012) that the benefits of screen-based media technology such as mobile applications are not well understood, and more research is needed to understand the potential for such technologies to promote learning and development (AAP, 2012). To examine the potential benefits of mobile apps on young children's learning and development, it is useful to understand the developmental needs of children at this age. NAEYC (2012a) wrote, "When used appropriately…technology and interactive media have the potential to enhance, without replacing, creative play, exploration, physical activity, outdoor experiences, conversation, and social interactions" (p. 2). This list of potential benefits highlights the wide range of possibilities for interactive media technologies such as children's mobile apps to enhance various aspects of children's development. However, there is little information on exactly what types of content can promote and enhance these developmental needs. Without this information, it would be difficult for app creators to design developmentally appropriate content, for practitioners to evaluate which pieces of content would be appropriate for their use, and for researchers to examine the potential of this technology for promoting optimal development in preschool children.

1.2 Theoretical Perspectives

To understand the potential of children's mobile apps to support and foster young children's development, the present study is influenced by two theoretical perspectives within child development research: *Developmentally Appropriate Practice* (Bredekamp & Copple, 1997) within the field of early childhood education and *Positive Technological Development* (Bers, 2006, 2012) within the field of applied child development.

Developmental Appropriate Practice (DAP) describes an approach to early childhood education and care that rests on research regarding children's development. The goal of DAP is to promote practices and experiences designed to foster children's optimal development. To this end, DAP encourages practitioners to base their practices on three core considerations: (1) practices that reflect child development research; (2) practices that take into account the individual needs of each child; and (3) practices that take into account the socio-cultural context of each child's development. The notion of Developmental Appropriate Practice has been widely applied in the field of early childhood care, early childhood education, and in curriculum planning (NAEYC, 2009). More recently, DAP has also been applied to evaluate appropriate usage of media technologies such as television and computers (NAEYC, 2012a).

While this framework has thus far been used by practitioners as a general guideline to evaluate the types of media content appropriate for preschool children (NAEYC, 2012b), it comes short in defining the types of content that promote specific areas of children's development. To supplement the DAP framework, this study also references the ongoing work on *Positive Technological Development* (Bers, 2006) to provide a vocabulary and a framework for understanding the potential benefits of technology on children's development. Bers (2006, 2012) put forth the Positive Technological Development (PTD) framework and proposed technologies engaging children in activities and behaviors indicative of communication, collaboration, community-building, content creation, creativity, and positive conduct can promote healthy development in young people. These activities, Bers hypothesized, would then lead to positive developmental outcomes called developmental assets. Bers' rather comprehensive framework, which is itself rooted in Lerner et al.'s (2005) *Six C's of Positive Youth Development*, provides a lens to evaluate the content of mobile apps for young children.

This study leverages the PTD framework as a way to organize and evaluate the role of technology in children's development. The framework is inherently multifaceted, encompassing the social, personal, and cognitive aspects of children's learning and development. It can be used as a tool for understanding and examining the various ways in which technology could impact children's development. The PTD framework has only been previously applied to contexts involving desktop computers and technological extensions such as robotics and programming, as well as for school-aged children (Bers, 2010; Bers & Chau, 2010; Bers et al., 2010). As such, little is known about the application of this framework on preschool children. This study aims to address this dearth in the literature and extends the PTD framework to preschool children between the ages three and five in the context of mobile apps use.

1.3 Purpose of the Study

As a designer of children's apps at *LeapFrog Enterprises, Inc*, the researcher is intrigued by what the new space of children's apps offers to promote positive technological development. As such, the purpose of this study is to examine the extent to which mobile tablet software applications produced for preschool children are designed in accordance with developmentally appropriate practices and with an intention to promote PTD. Thus, the subject of this study is to delineate design practices that are developmentally appropriate and the ways in which mobile apps can promote the various developmental needs of preschool children. The formal research question is:

What are developmentally appropriate ways to design mobile apps to support positive technological development for young children?

An important part of this study is a consideration of the various domains of preschool children's development mobile technology has the potential to support. The discussion will begin with an exploration of the developmental needs of preschool children between the ages of three and five as they relate to PTD. This is followed by a content analysis of the children's mobile apps landscape to examine the extent to which currently available content addresses these developmental needs in developmentally appropriate ways. To this end, the study asks the following questions:

1. What areas of preschool children's development are currently available mobile apps designed to address?
2. To what extent are these mobile apps designed in developmentally appropriate ways to support the developmental needs of preschool children?
3. In what ways are currently available apps designed to engage children in activities that stimulate positive technological development?

The following chapters address these three questions. Chapter One, this chapter, provides an overview of the dissertation. Chapter Two examines the historical and contemporary perspectives of children's tablet use, and extends the DAP and the PTD frameworks to the context of the present discussion. Chapter Three describes the methodology for the present investigation and discusses the various instruments devised to evaluate currently available children's apps. Chapter Four presents the results of the content analysis with particular attention to the ways in which these apps are designed in a developmentally appropriate way to promote PTD. Finally, Chapter Five closes with a discussion of the findings and argues for the need for mobile apps purposefully designed to promote optimal development in preschool children.

In sum, this study applies a developmental lens to examine the children's mobile apps landscape. In doing so, it offers an extended theoretical framework, underscores design principles, and highlights feature exemplars to support future content development and research efforts in this area.

1.4 Delimitations

The space of children's mobile apps is wide and deep. There are two major players in the industry: Apple's iOS App Store and Google's Android Play Store. Each of these two libraries contains more than 100,000 applications including games, learning aids, and utility software applications advertised as educational or intended for children. Furthermore, unique to the children's tablets market are other less popular players such as Fuhu's Nabi and Nabi Jr. that run on the Android platform, LeapFrog's LeapPad tablet and VTech's Innotab. This space is also in direct competition with handheld systems gaming systems such as the Nintendo DS and game consoles including Microsoft's Xbox Kinect and Nintendo's Wii. Each of these platforms has a distinct library of content and each platform offers unique affordances. Examining all of these various spaces would yield an unwieldy research project.

To provide focus, the delimitations of the study include:

1. In terms of scope, the study focuses on only iOS apps, specifically apps targeted at children between the ages of three and five years, available for download for free or for purchase on the Apple's iTunes App Store's "Kids" category.
2. In terms of relevance, the study looks at apps that are currently available on the Apple's iTunes App Store as of March 2014.
3. In terms of content, the study addresses apps that are specifically designed for the iOS platform, rather than content repurposed from other non-interactive sources such as television shows, or content intended to be used alongside tangible accessories or toys.

Chapter Two: Review of the Literature

Children's Tablet Technology Then and Now

For many years, it has been a tradition to attempt to cure our society's ills through technology. You have slums? Let's build low-cost housing!. Your kids aren't learning and education is too expensive? We'll build you a teaching machine for less, which will guarantee your kids will pass tests!

-Alan C. Kay, 1972.

2.1 Overview of the Literature Review

This study is an exploration of the children's mobile application software (i.e. "apps") landscape. As a new generation of computer technology, mobile tablets offer children novel ways to engage with digital content using innovative human-computer interfaces and advanced interactivity. These tablets come in different physical sizes such as a 4-inch phone-sized tablet (e.g. iPhone Touch), a more common 7-inch tablet (e.g., iPad Mini, Kindle Fire), and a larger 10-inch full-size tablet (e.g., iPad, Nabi XD). With a simple gesture of a swipe, tap, or touch on a multi-touch screen, children can access thousands of electronic books, video games, software applications, Internet content, music, and videos. Unlike the desktop computers that came before, mobile tablets are portable due to their small size and could be equipped with mobile data or Wi-Fi connectivity, making them ideal for use anywhere and at any time.

The innovation and engineering achievement of the mobile tablet cannot be diminished, but an examination of any children's technology must take into account the role of the child and how he or she interacts with the technology. Papert (1990), in describing *technocentrism*, wrote, "The role that the computer can play most strongly has little to do with information. It is to give children a greater sense of empowerment, of being able to do more than they could do before." Thus, we should evaluate the impact of new mobile technologies on children against the types of activities and behaviors they engender. Are these behaviors appropriate and beneficial to children's optimal development? Does technology advance and augment these activities and behaviors in a meaningful way?

This chapter explores the historical and contemporary perspectives on children's mobile technology. Placing the child, rather than the technology, at the center of discussion, this chapter suggests a new framework for understanding mobile apps intentionally and appropriately designed to promote children's development.

2.2 Historical Perspectives on Children's Tablet Technology

Fewer that four decades ago, the computer was thought to be exclusive to those in research, the military, and the corporate business world. Since then, industrialized society has seen the emergence of a generation of children and youth who grow up with computer technologies of all types and use these technologies in manners that, in some way, surpassed the imagination of those who created them (Gardner & Davis, 2013). Today, computer technologies are pervasive in the households of the developed world, and are widely recognized as a "children's machine" (Papert, 1993). This generation of children grows up in a world saturated with digital media and computer-mediated experiences. These technologies could be seen as "one of the indispensable 'symbolic goods' of contemporary parenting" and that "investing in computers is…a way of investing in your children's future" (Buckingham & Scanlon, p. 109). Some researchers and writers have even asserted that, as "digital natives," American children can hardly imagine a world without digital technology (Palfrey & Gasser, 2008; Prensky, 2006; Tapscott, 1998). Those without are said to fall on the wrong side of the "digital divide" (Lenhart, 2003; Subrahmanyam, Kraut, Greenfield, & Gross, 2000). Apple's iPad epitomizes personal computing for this population of children.

Although early technologists speculated the potential for computer technologies to support children's learning and development, it took decades of imagination, research, and development to arrive at today's prevalence of children's software. This section tells the journey of the children's tablet.

2.2.1 Early Computer Software for Children

Certain aspects of children's software can be dated back to early thoughts and theories about learning and automated teaching. The notion of automating learning and teaching using machines preceded the invention of the modern computer. Skinner (1961) wrote about his invention of a *Teaching Machine*, a mechanical device that could administer a curriculum of programmed instruction automatically. This machine was grounded in Skinner's *behaviorist* perspective of operant conditioning. A tape of paper with a list of questions would be housed in the machine and the learner would answer these questions one at a time. After answering each question, the learner would operate a mechanism to reveal the answer and proceed to the next question. Thought to be useful from preschool aged children to adults, the potential of the Teaching Machine lied in its ability to produce immediate feedback and automatically and systematically advance the curricular content to new material at the learner's pace. Based on a report on the learner's activity, a teacher could then adjust the machine to present more or less sophisticated curriculum content at the next use to ensure that the curriculum would be at the appropriate level for each child.

Though limited in technical and mechanical affordances, Skinner's machine highlighted several critical directions and areas where early researchers wanted to explore. Advancement and development in computer hardware gave rise to new opportunities for content and curriculum design. During the early days, hardware and software research went hand-in-hand. The first children's software, *Oregon Trail*, was delivered on mainframe computers and cassette tapes for the Commodore PET in the 1970's. The Apple II led to the popularization of the floppy disk, which led to The Learning Company (TLC) and the Minnesota Educational Computing Consortium (MECC). TLC and MECC founded a new market of computer software targeted to children for educational and learning purpose. They were two publishing powerhouses of early children's software, with promises to make learning fun and innovative. In many ways, these early children's software grew roots out of a body of previous research and effort in educational software for higher learning.

One important category of children's software emerged out of educational computing research at the university level. Between the 1960s and the 1980s, computer-assisted instruction systems such as PLATO, developed at the University of Illinois at Urbana-Champaign in the 1960s dominated educational software. Educators and computer scientists saw the potential of such technology for supplementing instruction by offering drill-and-practice to anyone with an access to a terminal. Computer technologies, they believed, could automate the feedback and scaffolding process so onerous on the public school teacher. PLATO favored a branch content programming methodology and incorporated course materials into interrelated conceptual packages.

When a student satisfactorily demonstrated mastery over a topic, PLATO would adjust to the next level of content. In contrast, students who needed additional support would be directed back and forth through the lessons in a calculated manner until the concept was mastered (Van Meer, 2003). Using PLATO, students in the elementary through university levels accessed course content from mathematics to reading to foreign languages.

Early evaluation of PLATO's efficacy on elementary education was mixed. Swinton, Amarel, and Morgan (1978) found positive learning gains among students in grades four to six using the PLATO Elementary Mathematics Curriculum. However, the same evaluation study found negative impact on kindergarten and first grade reading achievement. Nonetheless, teachers found PLATO useful for individualizing curriculum to students' needs (Cherian, 2009).

The earliest group of educational software at the elementary level predominantly reflected the drill-and-practice pedagogy. The advent of commercial educational software and software for children was primarily concerned with automating instruction to mitigate the challenges arising out of increasing enrollment (Van Meer, 2003). Around the same time, outside of the commercial space, researchers were intrigued by other ways that computer technology could promote learning. Seymour Papert and colleagues created the Logo programming language as an educational tool for children to explore computer programming and computational logic (Papert, 1980). These researchers took a more constructivist learning approach and focused on learning through creating and expression ideas.

By late 1970s, after the release of the Apple II in 1977, educators and computer programmers began to think of new ways to approach computer-aided instruction that could support individualized or personalized learning. By borrowing elements and design approaches from the burgeoning video game industry at the time, educators and developers created a new category of content known as *edutainment* or *children's software*. A key pioneer in this innovation was a team at The Learning Company (TLC) cofounded by Ann McCormick in 1979. With an intention to replace learning experiences offered by the older generation of technologies such as PLATO, the edutainment industry released a line of software that combined learning with game play. These titles included *Oregon Trail* and *Number Munchers* from the MECC, *Reader Rabbit* from the Learning Company, and *Math Blaster* from Davidson & Associates. At its heart, the developers of these software applications looked to play and games as central to the learning process (Ito, 2009). During the early 1980s, these learning games were very popular and successfully created a market for computer software for children.

2.2.2 The Rise and Fall of the Children's Software Industry

Amidst increasing achievement concerns and educational demands typical of the twentieth-century home in the United States, American parents welcomed the children's software industry with open arms. These products promised education that was entertaining and engaging. For those families who could afford them, children's software was the needed healthy alternative to television or other leisure activities.

Ito's (2009) account of the children's software industry in its early days presented a rather tumultuous journey. The industry was initially occupied by educators and programmers with an ideal to create new ways to teach and learn. They saw the computer as a way to immerse children in learning tasks not possible in the real world. To them, a good piece of educational or children's software engages children in learning and applying skills to real-world problems (Ito, 2009, p. 39). The constructivist notion of education influenced early pioneers. In an unpublished 1984 *Harvard Business School* case study, McCormick stated,

> Our core values here involve our desire to prepare children for the computer age. We want to do that with technical excellence in computing. We want to use the very best mass market micros to do that, to do it playfully, engage the kids, involve them, get them excited about learning, give them an active goal so it's not sugarcoated pill where there's some dinky reward or something. It's really involving children in a way that they become totally excited about learning and forget that it's a task…. like building something with an erector set where you get totally lost in the process…building thinking skills, ability to analyze, to construct, to approach things from different angles, to think flexibly, to reason carefully, and to do that in a way that you're building something.

However, these ideals soon saw their downfall. Unlike the early educational computing initiatives, such as PLATO, that received financial support from institutions and the federal government, the edutainment industry targeted home consumers and soon found itself confronting the realities of the commercial marketplace. Innovation stalled at the height of the children's software industry in the 1990s due to many factors including the introduction of the Internet that changed the landscape of access to information and content. Although technology continued to advance, designers paid less attention to producing creative and novel content for children. As the forerunners like The Learning Company changed corporate hands, children's software became commoditized. Early pioneers like Ann McCormick left the industry or went into Internet-related businesses due to the changing landscape, smaller companies merged, and larger corporation acquired them. By the end of the 1990s, businesses that leveraged the Internet as well as gaming consoles such as the Nintendo GameBoy took center stage. When it comes to children's desktop software, only two prominent publishers, Mattel and Cendant, remained.

To streamline development, one technique used by the industry was to establish easily replicated content templates based on basic genres and interaction formulas. By using consistent underlying "engines," developers easily reproduced and repackaged, or "re-skin," previously successful titles with new themes and curricular topics – *Oregon Trail* became *Amazon Trail* and *Reader Rabbit* became *Math Rabbit*. The scope of developing adventure games such as *Oregon Trail*, which situated learning in relatable real-world or simulated problems, became too burdensome for the market. Instead, some publishers favored games that coupled drill-and-practice with entertainment. For example, games like *Math Blaster* embedded curricular problems and tasks within an otherwise unrelated game narrative, such as navigating an alien spaceship through space by answering addition questions (See Figure 1). In many instances, game play and curriculum became divorced or curriculum was a secondary consideration, at best. Much to these publishers' delight, they could re-skin the same game with different content and repackage it for sale.

By the late 1990s, cookie-cutter children's software dominated the market alongside the proliferation of home personal computers (PCs). The reproduction of established game genres and formulas meant that the industry could produce more and do it cheaply, but the product was quickly becoming less progressive or transformational (Ito, 2009). There were a few smaller publishers and content developers such as Tom Snyder and Roger Wagner that continued to champion more innovative and constructivist approaches. For example, Roger Wagner's HyperStudio series gave young learners tools to learn through creating interactive art work and self expression. But at the turn of the millennium, the sales of children's software dramatically declined from 498 million in 2000 to 152 million in 2004. By then, technologists and researchers had looked to alternative spaces for innovation in children's technology. In the home desktop consumer space, the public became preoccupied with what the emerging Internet had to offer, including access to free educational content and web-based games for children. The rise of handheld gaming systems and gaming consoles also took over a large portion of the toy and children's media market. In 1999, *LeapFrog Enterprises, Inc.* launched the *LeapPad* reading system, which was a toy that integrated physical books with a touch-sensitive stylus interface to provide digitally enhanced interactions for early literacy. Across the country, various institutional projects such as the Fifth Dimension and the Computer Clubhouse emerged to offer children access to computer technology. Soon, the conversation changed from putting content in front of students to putting computers in the hands of children. In 2005, the *One Laptop per Child* project created a low price laptop with the goal of providing every child his or her own computer.

Figure 1. A screenshot from the game Math Blaster.

Note. Retrieved from http://www.gamefabrique.com/games/math-blaster/

2.2.3 Conceptualizing the Children's Tablet

Long before the days of the XO laptop or the iPad, and even before the emergence of the Xerox Parc, early computer pioneer Alan Kay envisioned a personal computer for children resembling today's tablet computers (Richard, 2008). Inspired by the educational philosophy of Jerome Bruner and the work of Seymour Papert, Kay conceptualized a device in his 1972 article, "A Personal Computer for Children of All Ages" (Kay, 1972). In it, he proposed and laid out the design for a tablet or slate computer, firstly named the KiddiComp and then later renamed the DynaBook, that had "the attention grabbing power of TV, but controllable by the child rather than the networks. It can be like a piano…which can be a tool, a toy, a medium of expression, a source of unending pleasure and delight" (Kay, 1972, p.1).

The technology needed to support Kay's DynaBook had not been invented. Kay along with fellow Xerox technologist Chuck Thacker built an interim model called the Alto. Although the Alto was not very successful in the commercial market, it was the first networked personal computer (Gasch, 2005). The Alto used the fundamentals of the graphical user interface (GUI), which was a trailblazer in 1972, to guide user interaction. Graphical user interface made computing for children more conceivable. Xerox chose not to invest in Kay's ideas for the DynaBook and it never materialized. However, others saw the Alto as laying an exciting groundwork for the next steps in the development of laptop computers and tablets.

Although today's technology has in many ways surpassed Kay's initial speculations, what's more foretelling in Kay's 1972 article was his depiction of two children, Jimmy and Beth, on the fictional DynaBook:

> Beth and Jimmy needed to find some information to answer a question about speed and the sun from their teacher. Using his network-capable DynaBook, Jimmy accessed the local library to research his topic without leaving his class. When Jimmy found something interesting that he wanted to review later, he simply copied it to his DynaBook. By connecting her DynaBook with Jimmy's, Beth was able to access his information. Through a simulation game and reflecting on recently learned knowledge, Beth and Jimmy arrived at new understanding about the speed and trajectory of the sun (Kay, 1972).

The scenario was remarkably similar to what today's tablets afford children and learners. Despite the DynaBook never coming into existence, Kay's imagination and innovation left a legacy in the history of digital computing for children.

2.3 Contemporary Perspectives on Children's Tablet Technology

Today's tablet technology owes its success to a long history of innovations. From the RAND Tablet in 1964 to the Apple II Graphics Tablet in 1979, and from the KoalaPad in 1984 to Apple's Newton and the PalmPilot in the early 1990's, decades of research and development brought the arrival of the Apple's iPad in 2010. Within a year, toy companies like *LeapFrog Enterprises, Inc.* released lower cost, sub-$100 versions of touch-based tablet designed specifically for children and educational entertainment. Alternatively, publishers began to offer children's educational content on handheld gaming devices such as the Nintendo DS. Today, numerous brands and types of "toy tablets" are available on the market. Each tablet choice offers access to a unique library of content. Adult or family tablets such as the Apple iPad and the various versions of the Android tablets offer the largest libraries. With decreasing technology costs, the boundary between toy tablets and adult tablets is closing (Buckleitner, 2012), and the key differentiator among the various tablet options, for adults or children alike, is the content that they access.

Although tablet computers for young children are becoming widely available, research on the impact and efficacy of these technologies and applications has yet to catch up. Researchers, educators, and practitioners share mixed perspectives on young children's use of these new technologies. This next section examines the current landscape and contemporary perspectives of children's tablets and mobile apps in the classroom and home settings.

2.3.1 Mobile Apps in the Classroom

The question of how young children interact with tablets and mobile apps is multifaceted. In addition to the content that the tablet can access, the technology itself poses an interesting issue for those concerned about children's development. Researchers and educators have only begun to investigate closely the impact of these technologies on adolescents (Gardner & Davis, 2013). Although many have raised concerns about young children's use of mobile tablets, research with young children is even more limited. As with the technology of the previous generation, research on young children's tablet use began in the classroom.

An earlier generation of research on children's use of the desktop computers in the classroom lays a partial foundation to the current discussion. In a review of the literature, Vernadakis, Avgerinos, Tsitskari, and Zachopoulou (2005) found that computers had the potential to assist instruction in the preschool classroom as they offer access to images, sound, and other materials – materials that otherwise would be difficult for teachers to acquire – to enhance the learning experience. Similarly, Haugland (1999) and Arrowood and Overall (2004) found increased motivation among kindergarten and elementary-age children when instruction was paired with the use of computers. Several researchers (Guthrie & Richardson, 1995; Talley, Lance & Lee, 1997) observed that children seemed to find computer activities naturally appealing and spent a longer time on computer-based activities than on similar activities in a non-computer scenario. More recently, researchers found positive results with stylus-based computing devices, especially in the area of handwriting (Borse & Sloan, 2005) and in art and drawing (Matthew & Seow, 2007).

When it comes to the modern tablets, preliminary research points to a great educational potential for young children. Geist (2012) investigated the manner in which young children interacted with tablets such as iPads versus traditional computers by introducing them to these devices in the same way they would introduce traditional exploratory toys like play-dough in the preschool classroom. Geist found that children as young as two easily adapted to the intuitive interface of the touch-based tablet. Children explored with these devices with greater independence than they would with traditional desktop computers. As such, the desktop computer stimulated less exploratory behavior and engagement when compared to tablet devices because of their ease of use.

The introduction of the mobile tablet was a novel and welcomed addition to the preschool classroom. Couse and Chen (2010) investigated the viability of tablets for three to six year-old students by integrating tablets into their classroom curriculum. Despite their lack of familiarity with the tablets, the students seemed to take to the devices quickly and persisted through technical challenges. Through individual observations of 41 children using a tablet for a drawing lesson, Couse and Chen (2010) found that children's engagement with the activity was surprisingly high. Interviews with teachers revealed that children performed the assigned drawing tasks beyond what would be expected of them in a typical classroom setting.

A number of other case studies have demonstrated successful use of the iPad and similar devices to enhance and support children's development and learning, especially in the area of communication and social interaction. Dundon et al. (2013) examined two particular apps to support communication among children with autism spectrum disorders, and found that combining reinforcement techniques with iPad apps designed to facilitate communication (specifically *My Choice Board* and *Go Talk Now*) greatly improved the children's communication skills. Sandvik, Smørdal and Østerud (2012) found, with guided instruction from a teacher, kindergarten children in a multicultural and multilingual classroom were more likely to help and engage with one another around the iPad to complete class activities than when without iPads.

As tablets become more prevalent in the preschool classroom, researchers and educators have begun paying closer attention to academic applications to supplement classroom lessons. A study by Chiong and Shuler (2010) gave 90 children iPod Touch devices with two early literacy apps (*Martha Speaks* and *Super Why*) over the course of two weeks. Using pre and post assessments, researchers found that three to seven year-old preschool and early elementary children made significant gains in vocabulary and phonological awareness after the intervention.

A more recent study by Milman, Carlson-Bancroft, and Googart (2012) found positive results with their 1:1 iPad initiative. The school district provided 300 preschool to early elementary students with individual iPads over the course of one school year. These researchers found that the tablets most prevalently supplemented mathematics instructions and practice, using such apps as *MathBingo*. Moreover, teacher interviews indicated that the tablets were most helpful when they differentiated the curriculum so teachers could offer different levels of content to students based on student progress.

Despite these and other educational apps specifically designed to facilitate learning, educators and researchers continue to find the educational benefits of these technological devices might not necessarily stem from the devices themselves, but rather from the deliberate choice that instructors make. Among the wide selection of apps and programs, teachers have to select carefully ones they deem useful and then strategically integrate the technology into developmentally appropriate curriculum (NAEYC, 2012). As such, the researchers argued that preschool teachers can benefit from training and professional development to integrate mobile apps into the classroom in meaningful and authentic ways. The joint position statement from NAEYC and the Fred Rogers Center (2012) wrote, "The adult's role is critical in making certain that thoughtful planning, careful implementation, reflection, and evaluation all guide decision making about how to introduce and integrate any form of technology or media into the classroom experience" (p. 6).

2.3.2 Mobile Apps at Home

While mobile technology use in the classroom benefits from thoughtful implementation and curriculum integration, mobile tablet use by young children at home is often less deliberate. One of the most often cited concerns about children's media use relates to the screen-time debate. The rhetoric about screen-time vs. playtime gained traction after the release of the 1999 policy statement, "Media Use by Children Younger Than 2 Years," by the American Academy of Pediatrics (AAP, 1999). In their statement, the AAP raised serious claims and concerns about the role of screen-based media in the lives of young children. Excessive screen time could pose serious consequences on social development, parent-child interaction, and physiological maturation among infants and toddlers. Research has found parents who use television or other screen based media as virtual babysitters are likely to spend less time with their children, thus reducing opportunities that foster early social development and parent-child attachment. Furthermore, research suggested early screen-based media exposure could put children at risk as screens could over stimulate young children's developing brains (Napier, 2014). In the face of these concerns and citing the lack of evidence for educational and developmental benefits, AAP discouraged media use by children younger than two years and advised parents to limit screen-time for older children.

Although the children's media landscape has changed dramatically in the decade and more since the release of the original policy statement, the same concerns never ceased. The rise in popularity of mass-market screen-based electronics for children such as children's tablets has only strengthened AAP's position. In their revised statement published in 2011, the AAP reiterated their general sentiments about the potentially negative effects of screen-based media on young children (AAP, 2011). With figures as high as 75% of children 0- to 8- years having access to mobile devices including smart-phones and tablets (Common Sense Media, 2013), AAP's concerns resonate with parents, early childhood educators, and health professionals.

Most recently, the AAP has capitulated to recognize digital media as a part of 21st century family life. However, it continues to caution parents against screen-time for children and adolescents, and advises parents to set rules about media use at home (AAP, 2013). Given emerging evidence linking major health epidemics including childhood obesity (AAP, 2011b) and attention deficit (Schmidt & Vandewater, 2008) to an inactive lifestyle occupied mainly by sedentary computer use and passive media consumption, it is no wonder that these concerns remain in the general discourse on children and media.

Yet, broad and unqualified statements and perspectives such as those espoused in AAP's policy statement fail to consider the socio-cultural context and wide variability in young children's media consumption experiences at home.

Screen time is not only limited to the lonely child sitting in front of a TV, a computer, or a tablet screen. For example, researchers and scholars in the field of media studies (Barron, Martin, Takeuchi, & Fithian, 2009; Fisch et al., 2008; Fisch, Shulman, Akerman, & Levin, 2002; Takeuchi & Stevens, 2011) have championed parent-child joint media engagement, or sometimes called co-playing or co-viewing, as beneficial to children's learning and development.

Joint media engagement (Stevens & Penuel, 2010) refers to media experiences in which multiple people, such as a parent and a child, interact together alongside or with the media content. Joint media engagement may include viewing or reading passive content or playing and creating with digital media together. Furthermore, joint media engagement may take many different forms, such as when an adult and a child co-create using a virtual platform, when an adult provides support, guidance, and scaffolding to a child as the child engages with content, or when they engage in activities that requires direct adult input (Takeuchi & Stevens, 2011). In this way, joint media engagement is the newer form of co-viewing for interactive digital media.

Although the potential for joint media engagement is discussed, there continues to be conflicting evidence regarding the social dimensions of mobile technology use among young children. With mobile platforms such as tablets and smart phones, researchers have also found a new "pass-back" phenomenon wherein adults such as parents pass their own devices to their children to occupy their attention. With the pass-back effect, young children's media consumption is no longer restricted to the living room. Children sometimes as young as three years now have access to screen-based media anywhere and at any time, such as in the car or when queuing at a store. According to Chiong & Shuler (2010), children typically take these devices to play games or engage in other entertainment activities for about five to twenty minutes per session (i.e., each pass-back). With pass-back, parents might be co-present but not co-engaged. As such, the context for informal media consumption varies depending on the level of parent and adult engagement. Understandably, screen-time continues to be a concern and the debate remains a relevant topic among practitioners and researchers.

The pass-back effect is one example of the parents' role in children's digital media and technology consumption. As noted by the AAP (2012), parental involvement in the form of joint media engagement and setting media rules is critical to the health of children. Furthermore, Veldhuis et al. (2014) found that parenting style and home contexts are crucial determinants of screen time among children who are five years old. In a survey of over 3000 families, Veldhuis and colleagues found that children whose parents institute house rules concerning daily screen time spend about thirty minutes a day in front of a screen; this is in contrast to about two hours of screen time among children whose parents have no set rules at home. Furthermore, they found that parents who set rules at home were more likely to own a wider variety of screens at home and offer their children a more balanced media diet composing of television, computer, and game consoles. They found that children with an authoritative or authoritarian parent spent less time in front of a screen.

2.3.3 Content Matters

As a response to the screen-time debate, numerous organizations have argued that the real question is not *how much* media children should consume, but *what* they should be consuming. Practitioners such as Lisa Guernsey (2012) used the phrase *content matters* to refer to a notion that the quality and content of media are factors just as important as how much time children sit in front of a screen. While this notion might seem obvious – certainly, there is a difference between educational television shows like *Dora the Explorer* and "just for fun" cartoon shows like *SpongeBob SquarePants* – AAP's guidelines, which many deem somewhat draconian, do not take into account the nature of these differences.

Furthermore, the context of consumption matters just as much. David Kleeman (2010), in a response to the emerging meme "a screen is a screen is a screen" (Knorr, 2010), argued that the affordance of a platform from which media is consumed greatly influences the child's relationship with that content. For example, we should perceive a touch-based interactive tablet offering age-appropriate, educational content differently from the passive viewing of a television show. In their 2012 position statement, NAEYC delineated two types of media and defined interactive media as, "digital and analog materials…designed to facilitate active and creative use by young children and to encourage social engagement with other children and adults." In contrast, they described non-interactive media as technology tools and media content that "can lead to passive viewing and over-exposure to screen time" (NAEYC, 2012). As content is no longer considered all the same, the debate over the interactive nature of newer forms of media, such as tablets and interactive television and DVD shows, adds intricate nuances to our general discussion of children's media use.

The distinction between passive and active media consumption is not new. From a socio-cultural perspective, a number of scholars have written about the active nature of children's cultural appropriation of media (Dyson, 1997; Kinder 1991; Seiter, 1999). Rather than consuming media entirely passively, some screen-based media content such as television and video games offer children opportunities to appropriate these narratives and characters into their day-to-day play and imagination. However, some evidence indicates that socio-cultural, class, and contextual factors influence the extent to which children appropriate these media content into meaningful and imaginative play experience or simply imitate what they have seen (Seiter, 1999). Furthermore, researchers such as Singer (1980) as well as Anderson and Lorch (1983) proposed that the extent of cognitive and active engagement with screen media depends on the pacing of the content.

This is especially true for young children. For example, an overly busy and fast-paced television show might over-stimulate the senses of a young child and interfere with cognition and reflection. As such, he or she might tune out from the content. In some way, these responses harken back to McLuhan's (1964) notion of "hot" and "cool" media. Rather than a simple calculation of how much "screen time" should be allowed, we should be looking at the extent to which digital media engage a child's active participation. When it comes to interactive digital media, tablets with the right apps can offer digitally enhanced experiences that *demand* children's attention and active participation a simple touch or a swipe on the screen.

2.3.4 The Current Landscape

Given the push for developmentally appropriate interactive media and technologies for young children, the arrival of the iPad was heralded with much excitement, particularly by educators who saw great potential for use in student learning. Since the inception of the iPad, the popularity of tablets has risen rapidly among young children, from 8% ownership in 2011 to 40% in 2013 (Common Sense Media, 2013). This is coupled with an explosive growth of educational and children-target apps on the market. There are now more than 100,000 educational and children's apps on the Apple AppStore (Shuler, 2012). Sometimes termed the "Digital Wild West" (Guernsey, Levine, Chiong & Severns, 2012), the reach and scope of tablets and children's apps world are undeniably deep and wide, and often with little regulation or curation. This has raised many concerns among practitioners, researchers, educators, and even parents.

While apps intended for adult consumption chiefly have marketing and innovation concerns, apps for children are another matter entirely, especially when they carry claims about educational and child development benefits. For example, some apps claim to teach basic skills such as phonics (e.g., *SUPER WHY Phonics Fair*), number recognition (e.g., *Elmo Loves 123s*), handwriting (e.g., *Learn to Write with Mr. Pencil*), and vocabulary (e.g., *Endless Alphabet*), while others profess to build social skills or develop emotional awareness despite the pseudo-social nature of the child-to-tablet context. As well, there is an entire category of children's apps for fostering creativity and critical thinking, albeit all with unproven efficacy. These apps warrant more scrutiny and analysis, as their claims are thus far unregulated.

Interactive children's apps roughly fall into three categories: game apps, interactive eBooks, and open-ended utilities. Each category has its own design pillars, content perspectives, and affordances. Moreover, just as children's play is fluid, children's mobile apps tend to cross category boundaries. Nonetheless, this categorization is useful and sufficient for the present discussion.

The variety of children's mobile game apps is as wide as the video game industry. Numerous scholars have attempted to organize the array of games into categories or taxonomies. The industry organizes games into genres. Crawford (1982), an early video game pioneer, sorted games into skill-based or strategy-based categories. Similarly, Herz (1997) divided games into genres as action games, adventure games, puzzle games, role-playing games, and simulation games. More recently, Hunicke, LaBlanc and Zubek (2004) focused more on how the players perceive a game and they classified eight types of fun for games (Table 1). Their organization highlighted the dynamics between the game designer and the game player, with the game itself being the mediator.

Table 1. Hunicke, Lablanc and Zubke's Eight Types of Fun

Type of Fun	Description
Sensation	Games that evoke emotion and affect by manipulating visual and auditory features and the pace of the game. This type of game offers thrill or pleasure that is otherwise difficult to experience.
Fantasy	Games that create a make-believe world with activities that cannot be realized in the real world. This type of games emboldens players with make-believe powers that they otherwise cannot obtain.
Narrative	Games that engross players in a story that unfolds over a series of player interactions. This type of game places the players as influencers of the narrative, giving players control over the direction of the game's journey.
Challenge	Games with obstacles for players to overcome and test their skills. This type of game offers strong feedback loop and dynamic content progression to challenge and support the players' skill development.
Fellowship	Games that provide a digital framework for social interaction and cooperation. The dynamics of the game extend beyond the relationship between the player and the game, to the interactions among the multiple players of a game. At the extreme, this type of game is less about the game narrative or mechanics but the extent to which the games stimulate social interactions and give players a way to contribute to a group.
Discovery	Games that afford players a virtual space to explore and learn new things, such as the history of artifacts or the way things work. This type of game encourages players to learn new concepts or new knowledge through game play.
Expression	Games that create a safe space for players to express themselves while maintaining the rules of the game and its dynamics. Unlike an open canvas, this type of game situates creativity within a game narrative.
Submission	Pastime games that allow players to lose themselves in mindless tasks. This type of game tends to be repetitive and rarely engages the players' emotionally, affectively, or cognitively.

These categorizations, while useful, do not particularly address the unique space of children's games, especially those intended to promote learning and development. Squire (2008) offered a framework specifically for educational games and organized content into targeted games (puzzles and activities), linear games (narrative-based), open-ended sandbox games, and persistent worlds (virtual reality). In particular to targeted games as learning aids, Goodwin (2009) as well as Goodwin and Highfield (2012) proposed three broad classifications:

1. *Instructive apps* refer to drill-and-practice activities that deliver instruction and the player selects an answer as a response. These apps may or may not include tutorials and may sometimes focus solely on assessment.
2. *Manipulable apps* offer players digital manipulatives for guided discovery and experimentation of particular curricular concepts. As digital manipulatives, the activities fall within pre-determined and scripted parameters, but still offer players some level of freedom to explore.
3. *Constructive apps* reflect an open-ended design allowing players to create their own content or digital artifacts. These apps may or may not include tutorials or teaching elements. Unlike instructive apps, constructive apps tend to avoid assessments. They often provide space for players to create their own digital portfolio to reflect on or share with others.

Most recently, building on Squire's work and others, Richards, Stebbings, and Moellering (2013) offered eight categories of games for children: (1) drill and practice; (2) puzzle; (3) interactive learning tools; (4) role-playing; (5) strategy; (6)

sandbox; (7) action/adventure; and (8) simulations. No matter which particular taxonomy one finds most relevant, these various categorizations speak to the wide variety of content available for children in the mobile apps market.

The current landscape of children's mobile apps is quite broad, offering various content experimentations and explorations to find the next big hit or "killer app." Surely one could agree that content matters when it comes to children's digital media, but exactly what content is developmentally appropriate and beneficial to children is a more complex question to answer. Content may be designed to achieve different goals with particular pedagogies or design frameworks. The landscape of children's media offers a variety of content options from educationally or cognitively engaging exercises, to activities that build life-skills and foster healthy choices, to apps that encourage and promote social interaction. What is appropriate for an individual child depends on the age of that child, his or her developmental stage, and the socio-cultural context surrounding the consumption of such media content. As such, an examination of what content is *good* must begin with an understanding of the developmental needs of children.

2.4 Positive Technological Development for Young Children

From the standpoint of identifying the potential for technology to promote the developmental needs of children, this study grounds its theoretical perspectives in Bers' (2006, 2012) PTD Framework. The PTD framework provides a model for understanding and examining how the use of technologies or technologically enriched contexts can support human development. In particular, following the tradition of Applied Developmental Science and Positive Youth Development (Bers, 2006; Lerner et al., 2005), PTD describes the role of technology and technology-enriched contexts in fostering important development assets that can lead to positive and fulfilling life outcomes. The present study extends Bers' framework to the context of mobile apps for preschool children aged three to five years.

2.4.1 Positive Technological Development

As a theoretical model, the PTD framework consists of three main components: developmental assets, technology-mediated behaviors, and a context of practice. Borrowing language from the Positive Youth Development (PYD) movement (Lerner et al. 2005), PTD refers to the developmental assets of competence, confidence, character, caring, connection, and contribution. These six individual assets, termed the *Six C's of PYD*, are qualities of youth that can steer them toward positive life outcomes and achievements. When put into the context of technological environments, Bers posited that technological experiences fostering these individual assets should lead to positive developmental trajectories.

The second component of Bers' framework comprises the variety of technology-mediated activities and behaviors that contribute, foster, and stimulate the six individual assets. These behaviors include technology-mediated communication, collaboration, content creation, community building, creativity, and choices of conduct (Bers, 2012, p. 13).

The extent to which a particular technology or technological intervention supports these activities and behaviors depend largely on the design affordances of that particular technology, the context of that technology use, and the dynamics between the participants and the technology itself. While not all technologies facilitate all six of these activities, technologies promoting any or all of these activities contribute to the overall development of the participants and guide these participants toward a positive developmental trajectory.

Technology is never used in a vacuum, but in a socio-cultural context with its own ecological and environmental characteristics. The third component of Bers' framework, context of practice, refers to the parameters and unique attributes of the social context around which a technological intervention is implemented. The context of practice may include elements that supplement and enrich the technological intervention, such as teacher guidance or peer collaboration, or it may include elements that hinder the efficacy of the technology. As such, while Bers' framework takes into account the design features of a technology for promoting development, she also places a strong emphasis on the context of use. For example, the classroom context in which a teacher integrates technology use to supplement a lesson is different from an informal learning context in which a museum uses technology as a substitute for a docent. Similarly, the home environment poses nuanced characteristics such as opportunities for joint experiences between a parent and a child, or shared play experiences between siblings and peers.

Bers (2012) illustrated the relationship between these three components of PTD using the diagram in Figure 2. Note it intentionally leaves blank the elements under context of practice as they reflect specific elements of a particular intervention or technological context.

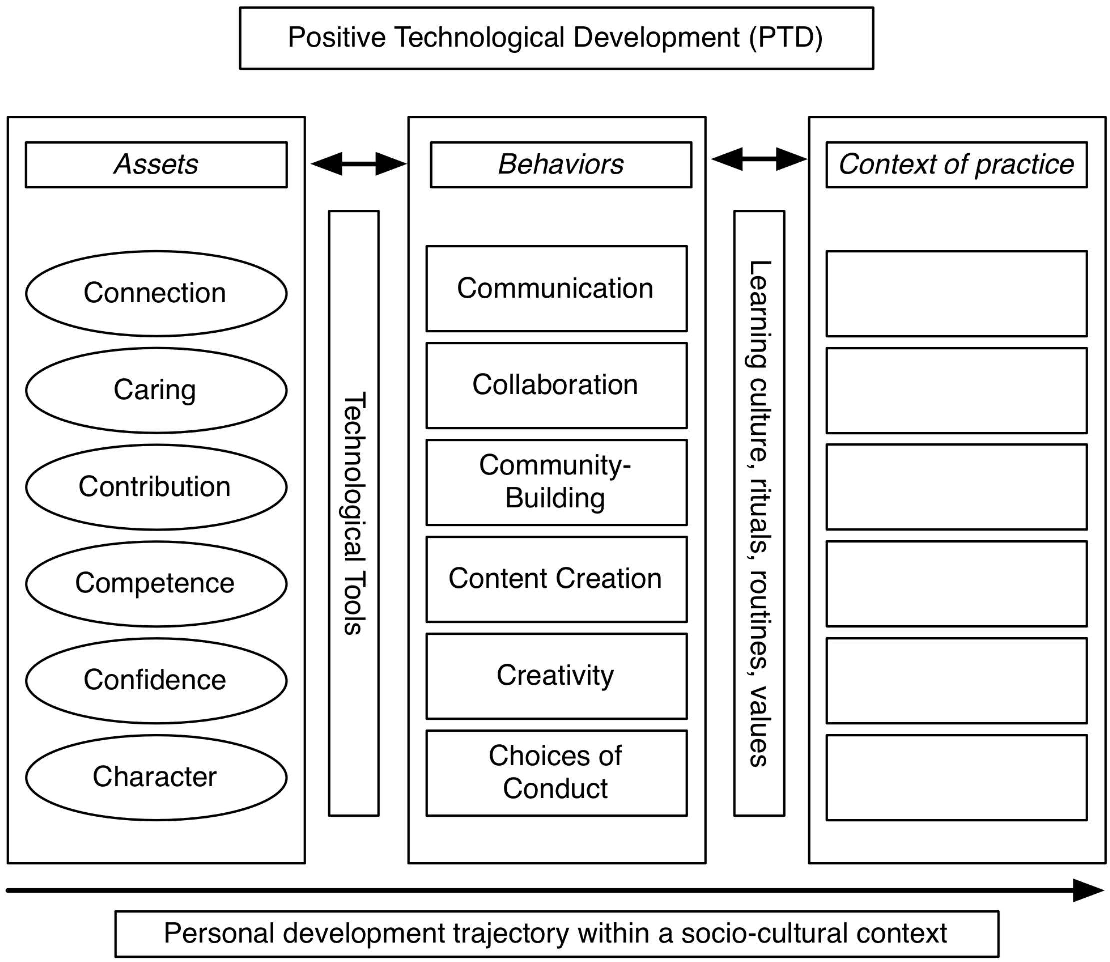


Figure 2. The *Positive Technological Development* framework.

Note: From "Designing Digital Experiences for Positive Youth Development" by M. Bers, 2012, p. 13. New York: Oxford University Press.

2.4.2 Positive Technological Development for Young Children

Bers' (2012) PTD framework described various types of technologies for school-aged children, including virtual environments for learning and care, robotics and engineering curriculum, visual programming languages for children, and applications for children to design and produce their own digital artifacts. However, researchers have not fully explored this framework with respect to young children between the ages of three and five, nor have they considered it in the context of mobile apps. The present study extends Bers' framework to the young child. The focus on young children aged three to five acknowledges the unique stage of the preschool child and the developmental considerations and needs of this particular population. To that end, the discussion begins with an examination of the developmental goals and needs of preschool children relating to the six developmental domains of PTD.

Bers hypothesized technology-mediated activities affording children an opportunity to create content can promote the developmental asset of competence. Grounded in the work of Papert's *Constructionism* (1980), content creation allows young technology users to manipulate virtual tools to exercise and hone their knowledge to create personally meaningful artifacts. For young children, learning and cognitive development happens through the dynamics between individual actions and social interactions. Pre-operational children during the preschool years (roughly aged three to five years) enter the intuitive thought sub-stage. Preschool children are beginning to explore logic and reasoning and discover new abilities as they encounter new experiences (Piaget, 1952). To do this, children experiment, explore, and adopt knowledge and skills through a series of assimilating and accommodating new concepts.

The role of education, then, is to provide children with new experiences still within their reach. The distance between what a child, or a learner, can do without help and what he or she can do with guidance and support is called the *zone of proximal development* (Vygotsky, 1978). Learning happens when children are guided through this zone of proximal development with proper scaffolding and support. Due to their adaptive nature, digital technologies can offer scaffolding support dynamically to cater to each individual learner. Gee (2003) called this the "explicit information on-demand and just in-time principle" (p. 138). Miliband (2005), in particular, called for technologies that can dynamically adjust content to personalize and individualize learning.

Bers hypothesized technology-mediated activities allowing children to express themselves in creative ways can promote the developmental asset of confidence. Underlying this concept is the freedom to "transcend traditional ideas, rules, patterns, relationships, or interpretations create and imagine original new ideas" (Bers, 2012, p. 12). For preschool children, this type of freedom takes the form of finding purpose in what they do. According to Erikson's stage theory of psychosocial development, children at this age confront the challenge of taking initiative or feeling guilty about their choices (Erikson, 1950). Children need opportunities to do things on their own in developmentally appropriate ways, with proper guidance and support that scaffold the experience. The freedom to take initiative allows children to develop their self-worth and a sense of accomplishment (Harter & Pike, 1983).

In particular, preschool children between the ages three and five are very concrete in their thinking, including their perception of the self. They show little awareness or care about how they compare to others, and their description of the self tends to stem from their physical attributes ("I'm THIS big!"), possessions ("I have THIS toy"), activities ("I go to preschool"), or skills ("I can do THIS myself"). While their inflated self-esteem gives young children the enthusiasm to explore and try new things, they are also easily influenced by external evaluation and rewards in the form of concrete praise or tokens (Berndt, 1997).

Bers hypothesized technology-mediated activities helping children communicate with peers to share thoughts, opinions, and information can promote the developmental asset of *connection*. New forms of technologies such as social media platforms promote new ways for building social relationships and expanding one's social network. For preschool children, Sullivan (1953) emphasized the development of speech and communication skills as critical in this stage of social development. According to Sullivan, language allows children to coherently organize their experience into memory and develop categories (which he calls *personifications)* to organize their social network. He argued that this ushers in the need for playmates, which he calls, "chums" or co-equals. Unlike playmates of toddlerhood that may be ephemeral, chums are friends that endure multiple social occasions.

Sullivan posited that chums are the first true interpersonal experience based on reciprocity and exchange, and that the effect of chumship is to promote self-validation through shared experiences such as play. Although chums and best friends begin to form during the preschool years, researchers find that preschool children also play with a wider range of peers than do toddlers (Howes, 1983). In this context, technology-mediated activities allowing children to communicate with peers over time in a joint media experience would be valuable.

Bers hypothesized technology-mediated activities encouraging children to collaborate can promote the developmental aspect of *caring*. For preschool children, collaboration takes the form of shared play experiences as children develop expanded cognitive and social abilities to play with their peers (Bretherton, 1986; Selman, 1980). According to Parten (1932), preschool children transition across three phases of social play scenarios. The youngest among the preschool aged children might engage in parallel play – a scenario in which multiple children play independently beside each other and do not involve or influence each other's activity. From parallel play children progress to associative play – a scenario in which children communicate and join in a common activity such as sharing play materials, but continue to focus their play on what interests them rather than the group. As children near the upper preschool age, they might engage in cooperative play – a scenario in which children play together with a commonly shared objective such as a competitive game or collaborative project.

Although subsequent research challenges the linearity of Parten's categories (Moore, Evertson, & Brophy, 1974; Rubin, 1982), scholars agree that collaboration in the form of social play becomes more prominent during the preschool years. Compared to previous years, children at this age gain increased social contacts with same-aged peers, with longer social episodes and more varied social experiences (Blurton-Jones, 1972; Holmberg, 1980; Rubin, Watson, & Jambor, 1978). To this end, technologies promoting preschool children's caring and collaborative behaviors should guide children toward shared play experiences with scaffolds to support shared play narratives for extended episodes.

Bers hypothesized technology-mediated activities encouraging children to make choices about conduct and behaviors can promote the developmental asset of *character*. With virtual technologies, children can explore "what if" situations and observe consequences of their actions in a safe and secure virtual context. For preschool children, these choices reflect their understanding of rules and punishment. According to Piaget (1932/1965), preschool children are in the stage called *morality of constraint*. Children at this age tend to think of right and wrong in black and white terms. These terms are typically conditioned by the rules that have been imparted to them and the punishments that ensue should these rules be violated.

Because children at this age think in preoperational terms (Piaget, 1952) and lack an understanding of the social and dynamic nature of rules, they might believe that justice is immanent – that is, transgression will result in punishment even when there are no witnesses. Kohlberg (1984) extended Piaget's work on moral development to notions of fairness and justice. In Kohlberg's view, preschool children typically exercise morality with pre-conventional thought. Similar to

Piaget, Kohlberg found that the typical young child's moral decisions are grounded in consequences and punishment, which he called *stage one* of pre-conventional thought.

Simply put, young children make decisions to avoid punishment. As the child's cognitive abilities mature, this punishment-avoidance mentality broadens to *stage two* of pre-conventional thought, which includes self-interest driven decisions. During this stage, children's reasoning for moral decisions is defined by the outcomes that could benefit the self rather than the group. While avoiding punishment continues to be a factor, other outcomes such as material gains, friendship maintenance, and praise and rewards are also considered.

Given young children's limited, egocentric, and pre-operational view of morality, early childhood educators (e.g., Crosser, 1996) have advocated for curriculum that allows children to experience moral conflicts among peers, to make and change rules, and to explore the concepts of intentions and motives behind moral behaviors. Technology-mediated content that aims to promote this developmental asset, therefore, should take into account children's limited understanding of the dynamic nature of morality and rules. Simulations of rules, behaviors, and consequences should respect this developmental stage and present rules and consequences in simple manners.

Bers hypothesized technology-mediated activities helping children participate and support a community through actions and behaviors can promote the developmental asset of *contribution*. For preschool children, contribution and community building take the form of pro-social behaviors such as sharing and helping. Research on television media has shown that children can acquire pro-social behaviors by observing an adult or a peer model who helps and shares with others. For example, children who watch television shows such as *Mister Roger's Neighborhood*, in which adults and characters demonstrate pro-social behaviors showed increased social interaction, sharing behavior, cooperation, and positive social skills with peers (Comstock & Paik, 1991; Huston et al. 1992). For young children, pro-social behaviors are greatly influenced by positive feedback and reinforcement (Eisenberg, 1992).

Based on this review, a revised PTD framework for young children is presented in Figure 3.

2.5 Developmentally Appropriate Practice in the Context of Apps

It is not sufficient to design children's content with an intention to promote optimal development or developmental assets. Children's content must also take into account the unique abilities and needs of young children. Well-designed digital content in the context of children's mobile apps must begin with an understanding of children's development. NAEYC (2012a) maintained, "The effectiveness of technology and interactive media, as with other tools, depends on their being used in the right way, under the right circumstances, by those skilled in their use. Within the framework of developmentally appropriate practice, this means recognizing children as unique individuals, being attuned to their age and developmental level, and being responsive to the social and cultural context in which they live" (p. 1). While the framework of developmentally appropriate practice has been applied to

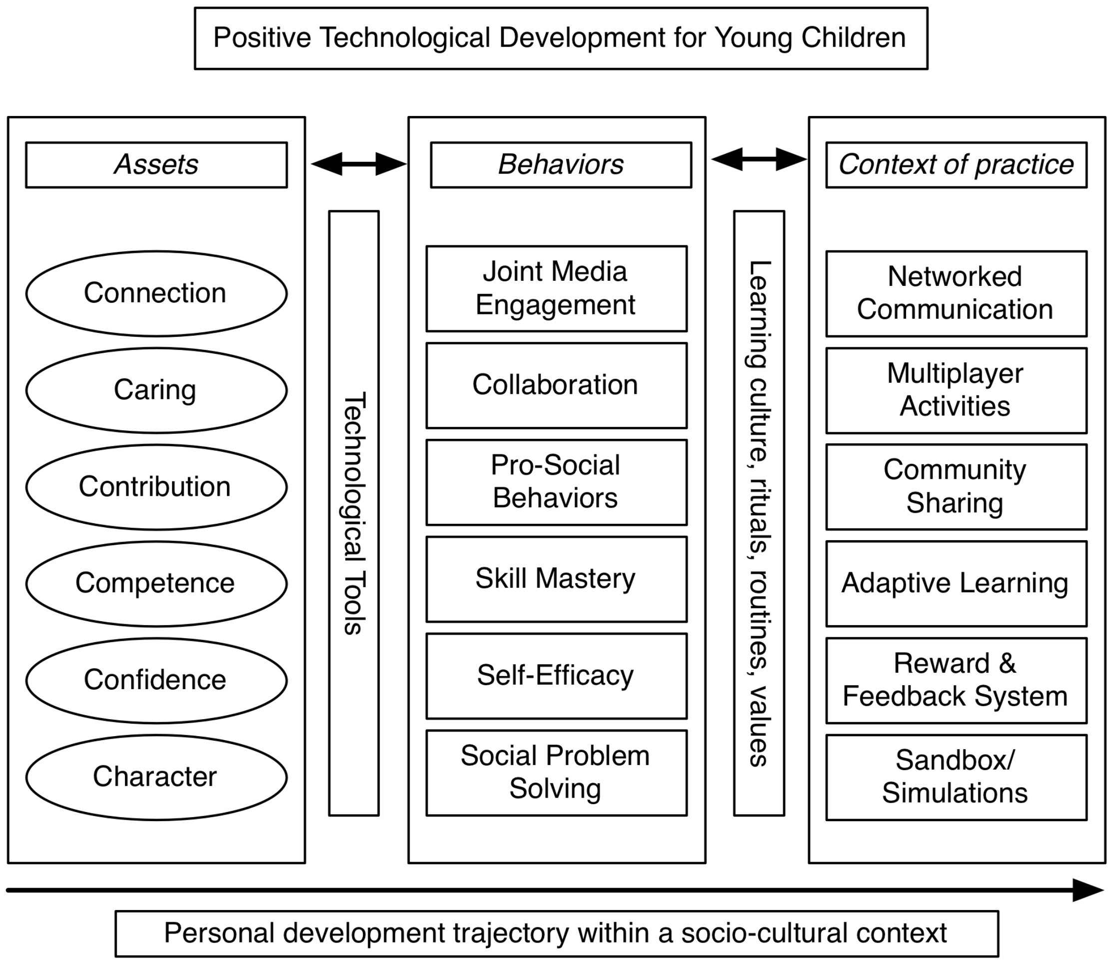


Figure 3. The *Positive Technological Development* framework for young children.

various contexts of children's lives, it has not been extended to mobile apps for preschool children. Given the rapid growth of mobile technologies and mobile apps as a popular medium for children's media consumption, entertainment, and enrichment, it is critical that research efforts are dedicated to conceptualize what developmentally appropriate practice means in this new context (NAEYC, 2012b).

2.5.1 Developmentally Appropriate Practice and Children's Technology

Three theoretical pillars underlie the term *developmentally appropriate practice* (DAP): (1) practices should be based on theories of child development research; (2) practices should accommodate the individual strengths and needs of each child; and (3) practices should reflect the socio-cultural background of the child.

At its core, DAP is about meeting children where they are – developmentally, socially, and culturally (NAYEC, 2009). Conceived as a framework for teaching practices, DAP asks early childhood educators and teachers to consider the unique attributes and needs of each child and, armed with knowledge of child development research and theories, design learning experiences suited to the child's learning and developmental stage yet challenging enough to promote engagement and progress.

Reflecting on these principles and the general framework, NAEYC and the Fred Rogers Center conceived and released a joint statement on developmentally appropriate technology and interactive media use with young children (NAEYC, 2012). The joint statement reiterates the importance of creating technology responsive to the developmental levels of children, to their individual needs and interests, and to their social and cultural contexts. In particular, they emphasized the distinction between interactive and passive media, stating,

> Interactive media refers to digital and analog materials, including software programs, applications (apps), broadcast and streaming media, some children's television programming, e-books, the Internet, and other forms of content designed to facilitate active and creative use by young children and to encourage social engagement with other adults. (NAEYC, 2012, p. 1)

The position statement offers 14 guiding principles for integrating technology in the early education classroom (NAEYC 2012):

1. The use of technology tools and interactive media should not harm children.
2. Developmentally appropriate practices must guide decisions about whether and when to integrate technology and interactive media into early childhood programs.
3. Professional judgment is required to determine if and when a specific use of technology or media is age-appropriate, individually appropriate, and culturally and linguistically appropriate.
4. Developmentally appropriate teaching practices must always guide the selection of any classroom materials, including technology and interactive media.

5. Appropriate use of technology and media depends on the age, developmental level, needs, interests, linguistic background, and abilities of each child.
6. Effective uses of technology and media are active, hands-on, engaging, and empowering; give the child control; provide adaptive scaffolds to ease the accomplishment of tasks; and are used as one of many options to support children's learning.
7. When used appropriately, technology and media can enhance children's cognitive and social abilities.
8. Interaction with technology and media should be playful and support creativity, exploration, pretend play, active play, and outdoor activities.
9. Technology tools can help educators make and strengthen home-school connections.
10. Technology and media can enhance early childhood practice when integrated into the environment, curriculum, and daily routines.
11. Assistive technology must be available as needed to provide equitable access for children with special needs.
12. Technology tools can be effective for dual language learners by providing access to a family's home language and culture while supporting English language learning.

13. Digital literacy is essential to guiding early childhood educators and parents in the selection, use, integration, and evaluation of technology and interactive media.
14. Digital citizenship is an important part of digital literacy for young children.

In addition, the position statements calls for additional professional development and training opportunities for teachers and early childhood educators on these principles, as well as further research to better understand how young children use and learn with interactive media.

2.6. A Framework for Developmentally Appropriate App Design

The discussion on developmentally appropriate technology use among young children demands that practitioners use child development knowledge and theories to guide the selection of interactive media to ensure developmental appropriateness. However, NAEYC's position statement falls short on giving precise definitions and guidelines as to what constitutes developmentally appropriate interactive media design. Given the infancy of this industry, there is yet an authority to regulate the design of children's mobile apps.

2.6.1 Existing Guidelines for Children's App Design

Several organizations have released white papers with an attempt to identify key design principles. Their hope is to guide producers and creators of children's mobile apps, as well as parents and educators, as they select and incorporate apps into children's activities and curriculum. At a broad level focusing on general technology use in the classroom, McManis and Parks (2011) from Hatch, a company that focuses technology for early childhood education, offered the *Early Childhood Educational Technology Evaluation Toolkit* that translates the principles and sentiments of the joint statement to a rating scale. The evaluation toolkit includes 20 questions on a 4-point Likert-type scale to assess whether the piece of software is: (1) educational; (2) appropriate; (3) child-friendly; (4) enjoyable; (5) progress monitoring; (6) individualizing; and (7) integrating. Table 2 lists the items on McManis and Parks' evaluation form.

Haugland (1998) offers a similar instrument, the *Haugland Developmental Software Scale*, to evaluate software for young children. Whereas McManis and Parks' scale focused on the appropriateness of a piece of software for classroom use, Haugland's scale focused on the developmental appropriateness of a piece of software with items more detailed and specific than those found on McManis and Parks' scale. The Haugland Developmental Software Scale includes 38 polar questions (Yes/No) across 11 components: (1) age appropriate; (2) child in control; (3) clear instructions; (4) expanding complexity; (5) independence; (6) non-violence; (7) process orientation; (8) real world model; (9) technical features; (10) transformations; and (11) anti-bias. Table 3 lists the items on Haugland's scale.

Buckleitner (1985) offered a more comprehensive scale, the *Children's Interactive Media Rating Instrument* (see Table 4). It focused on five design categories: (1) Ease of Use; (2) Childproof; (3) Educational; (4) Entertaining; (5) Design Features. Unlike the other two scales, Buckleitner's scale places an emphasis on child-control, with questions such as, "The child has control over the rate of display" and "The child has control over exiting at any time." Buckleitner's scale has been used to evaluate and rate over 12,000 commercial interactive media products since 1985.

While McManis and Parks's and Haugland's scales closely reflected the joint statement by NAEYC and the Fred Rogers Center, these scales are intended to encompass all technology use in the classroom or by young children. Accordingly, they lack the specificity needed to focus on the particular affordances of a particular technology, namely the iPad. Furthermore, apps vary so widely in terms of content, scope, design, and pedagogy. Not one scale could capture all the parameters and variables necessary to evaluate all apps available on the market. For example, McManis and Parks' scale focused on the appropriateness of content and pedagogical features such as progress monitoring and individuation; however, the scale lacked attention to design features such as the use of visual and auditory elements to promote learning. Haugland's scale was more specific with the design of the software such as the use of colors and animations, as well as ease of integration into the classroom; however it lacked specificity on how technology should support scaffolding, individualized learning, or adaptive curriculum. Buckleitner's scale focused primarily on interface and design paid less attention to the context of use such as classroom integration than the other two scales.

Most recently, the Sesame Workshop (2012) released a white paper summarizing several best practices they have identified for designing apps for children. These are design tips based on their four decades of media development and testing as well as a review of over 50 touch screen studies. These tips are specific to modern tablets and reflect design approaches and philosophy held by

Sesame Workshop. They cover nine major categories: (1) use of characters; (2) interactive design; (3) intuitive gestures; (4) screen design; (5) text; (6) visual layout; (7) visual design; (8) audio design; and (9) intentionality. Table 5 summarizes key items from Sesame Workshop's white paper.

Table 2. Items on the *Early Childhood Educational Technology Evaluation*

Category	Question
1. Educational	a. Learning versus focus on winning? b. Content research or learning standards based?
2. Appropriate	a. Appropriate cognitive skills(s)/subject matter? b. Set in interesting/appealing context? c. Pre/non-reader can navigate? d. Free from bias?
3. Child-Friendly	a. Simple/clear choices? b. Multiple, positive opportunities for success? c. After adult support, children can use independently?
4. Enjoyable/Engaging	a. Enough activities with variety? b. Appropriate use of rewards? c. Realistic graphics and appealing to intended age? d. Activities match well to attention span?
5. Progress Monitoring	a. Covers all the key areas the software teaches? b. Easy to use and interpret?
6. Individualizing Features	a. Can be customized for child's needs? b. Allows creation of new activities?
7. Integration	a. Initial training on integration included? b. Ongoing training opportunities?

Table 3. Items on the *Haugland Developmental Software Scale*.

Category	Items
1. Age Appropriate	a. Realistic Concepts b. Appropriate Methods
2. Child in Control	a. Actors not Reactors b. Can Escape c. Children Set Pace d. Trial & Error
3. Clear Instructions	a. Picture Choices b. Simple, Precise Directions c. Verbal Instructions
4. Expanding Complexity	a. Low Entry, High Ceiling b. Learning Sequence is Clear c. Teaches Powerful Ideas
5. Independence	a. Adult Supervision Not Needed After Initial Exposure
6. Non-Violence	a. Software is free of violent characters and actions b. Software models positive social values
7. Process Orientation	a. Discovery Learning, Not Skill Drilling b. Intrinsic Motivation c. Process Engages, Product Secondary
8. Real World Model	a. Concrete Representations b. Objects Function c. Simple, Reliable Model
9. Technical Features	a. Animation b. Colorful c. Installs Easily d. Operates Consistently e. Prints f. Realistic Corresponding Sound Effects or Music g. Runs Quickly h. Saves Children's Work i. Uncluttered Realistic Graphics
10. Transformation	a. Objects and Situations Change b. Process Highlighter
11. Anti-bias	a. Multiple Languages b. Mixed Gender and Role Equity c. People of Diverse Cultures d. Differing Ages and Abilities e. Diverse Family Styles

Table 4. Items on the *Children's Interactive Media Rating Instrument*.

Category	Items
1. Ease of Use	a. Skills needed to operate the program are in range of child b. Children can use the program independently after the first use c. Accessing key menus is straightforward d. Reading ability is not prerequisite to using the program e. Graphics make sense to the intended user f. Printing routines are simple g. It is easy to get in or out of any activity at any point h. Getting to the first menu is quick and easy i. Controls are responsive to the touch j. Written materials are helpful k. Instructions can be reviewed on the screen l. Children know if they make a mistake m. Icons are large and easy to select with a moving cursor n. Installation procedure is straightforward and easy to do
2. Childproof	a. Survives "pound on the keyboard" or "digital playdoh" test b. Offers quick, clear, obvious response to a child's action c. The child has control over the rate of display d. The child has control over exiting at any time e. The child has control over the order of the display f. Title screen sequence is brief or can be bypassed g. When a child holds a key down, only one input is registered h. Files not intended for children are safe i. Children know when they've made a mistake j. This program would operate smoothly in a home or classroom
3. Educational	a. Offers a good presentation of one or more content areas b. Graphics do not detract from educational intentions c. Feedback employs meaningful graphic and sound capabilities d. Speech is used e. The presentation is novel with each use f. Good challenge range g. Feedback reinforces content h. Program elements match direct experiences i. Content is free from gender bias j. Content is free from ethnic bias k. A child's ideas can be incorporated into the program l. The program comes with strategies to extend the learning m. There is sufficient amount of content

4. Entertaining	a. The program is enjoyable to use b. Graphics are meaningful and enjoyed by children c. This program is appealing to a wide audience d. Children return to this program time after time e. Random generation techniques are employed in the design f. Speech and sounds are meaningful to children g. Challenge is fluid or a child can select own level h. The program is responsive to a child's actions i. The theme of the program is meaningful to children
5. Design Features	a. The program has speech capacity b. Has printing capacity c. Keeps records of child's work d. Branches automatically: challenge is fluid e. A child's ideas can be incorporated into the program f. Sound can be toggled or adjusted g. Feedback is customized in some way to the individual child h. Program keeps a history of the child's use over time i. Teacher/parent option are easy to find and use

Table 5. Selected tips from Sesame Workshop's App Design Best Practices.

Category	Items
1. Characters Use	a. Use familiar characters as "hosts" throughout.
2. Interactive Design	a. Begin with a character or narrator greeting the user. b. State the objective and how to accomplish it. c. Use inactivity prompts, 3-5 seconds eBooks and 6-8 seconds for games. d. Three levels of wrong answer scaffolds with audio and visual feedback. e. Visual and audio feedback as correct answer payoff. f. Encouragement feedback for non-assessed activities g. Context-specific instructions via dialogue, with thorough "How-To" instructions for parents
3. Intuitive Gestures	Intuitive: Tap, trace, swipe, drag, slide Unintuitive: Pinch, tilt, multi-touch, flick, double tap
4. Screen Design	a. Make game play goal visually explicit. b. Distinguish interactive elements from background. c. Consistent look and feel for similar functions. d. Use visual indicators to signal hidden elements. e. When needed, use horizontal scrolling. f. Use colors and borders to highlight hotspots. g. Ensure hotspots are large and adequately isolated.
5. Text	a. Avoid text instructions and text labels. b. Highlight text in an eBook as it is read aloud. c. Use simple, serif-less fonts such as Zaner-Bloser.
6. Visual Layout	a. Menu should be present and accessible at all times. b. Landscape view is preferred. c. Use typical scan directionality (left-right, top-bottom). d. Avoid the edge of the screen where the child might place his/her hands.
7. Visual Design	a. Accompany any audio instructions with visuals. b. Use sounds and visuals to indicate interactivity. c. Isolate hotspots from background with visual effects. d. Use icons that follow standard conventions.
8. Audio Design	a. Concise audio instructions with visual support. b. Use explicit and consistent interaction terminology. c. User input should interrupt unessential prompts. d. Recognize user input with sound effects. e. User sound effects or music to transition from narrative to interactive experience. f. Avoid background music that detracts from gameplay.
9. Intentionality	a. Register user input on touch rather than on lift. b. Use colors and recognizable icons in confirmation screens.

2.6.2 Developmentally Meaningful App Design

For the present discussion, a *developmentally meaningful* app is a children's mobile app designed with an intention to support children's learning and development. When it comes to developmentally meaningful apps, the existing guidelines describing the design guidelines, principles, and practices are necessary but not sufficient. At the minimum, children's mobile apps, as a form of interactive digital experience, must be designed appropriately to address the abilities of young children. Whether the app intends to entertain or to educate, *good* mobile apps need to be usable and compatible with what children can comprehend and do. Still, developmentally appropriate design is only a pre-requisite; good mobile apps should engage children in the type of meaningful activities and behaviors that promote optimal development. They should foster their confidence, expand their social connections, and build their character. Finally, they should address content relevant to the learning and development of children and enrich children cognitively, socially, emotionally, physically, and academically.

Together, these notions form the three pillars that make a mobile app meaningful to children's overall development and learning (Table 6). The explicit goal of this study is to examine the extent to which currently available apps are *developmentally meaningful*. The next chapter will describe the methodology of the present study that evaluates existing apps for their developmental meaningfulness.

Table 6. The Three Pillars of Developmentally Meaningful Mobile Apps

Pillars	Description
Design	Developmentally meaningful apps must be created with appropriate design features to accommodate the abilities of young children.
Dynamics	Developmentally meaningful apps must engage children in activities that promote positive technological development.
Content	Developmentally meaningful apps must address the cognitive, social, emotional, physical, or academic dimensions of children.

Chapter Three: Study Design and Methodology

3.1 Study Design Framework

As a contribution to a new field of study, the present study used content analysis techniques to explore systematically the burgeoning content of children's mobile apps to answer the question, "What are developmentally appropriate ways to design mobile apps to support PTD for young children?"

The rapid growth of the children's mobile apps landscape and the mass distribution of its content formed an ideal data corpus for content analysis. This allowed the researcher to gain deeper insights into how these apps were designed and their unique features that could promote children's development. As a research methodology, content analysis turns qualitative review of a body of content into quantitative descriptions that can be analyzed using statistical methods. Using qualitative coding as a technique, content analysis provides an "objective, systematic, and quantitative description of the manifest content" (Berelson, 1952, p. 18). This analysis allows the researcher to tell a story about what these pieces of content are designed to do, and whether they are designed in a developmentally appropriate way.

3.2 Data Corpus

3.2.1 Sampling Criteria

This study looked at children's mobile apps that were available on the Apple's *App Store*. The virtual marketplace contained over one million apps as of March 2014, with over 100,000 pieces of content marketed as educational and intended for children. To provide some boundaries, the study sampled content that satisfied the following criteria:

1. *iPad apps within the* Kids *category for ages 3-5*: This study focused on mobile apps for preschool children, so content had to be intentionally designed for this age group to be eligible. The Apple's App Store contained a "Kids" section that organized children's apps into three age brackets – 5 years and under, 6 years to 8 years, and 9 years to 11 years. This information informed sampling. In addition, where available, the researcher also referenced *Children's Technology Review* for their recommended age range.
2. *Full version*: Many apps offered a free trial in addition to the paid, full version. This practice was commonly employed as a marketing strategy to attract new customers. A free trial of an app typically contained a small portion of the content with limited functionality. To evaluate fully each app in the sample, the researcher downloaded and purchased all paid versions of the apps.
3. *Available as of March 15, 2014*: Given that the inventory of apps on the App Store grew and fluctuated daily, the "population" of the database was ever changing. For this reason, the researcher conducted sampling and the collection of the sample data corpus on the same day to avoid time-related bias and changes. The researcher did not consider apps that were not available on this date.
4. *English content on the US App Store*: At the time of the study, the Apple App Store was available in 126 countries and regions. The virtual marketplace in each of these regions offered a different selection of

content. The present study sampled content from only the United States App Store. Furthermore, because of the primary researcher's language proficiency, he only considered apps written and presented in English.

3.2.2 Sample Size

The researcher based his decisions regarding sample size on a review of comparable studies involving children's mobile apps and software with research designs involving content analysis and qualitative coding. Shuler (2012) conducted a content analysis of educational apps for children and included a sample of 100 iPad apps and 100 iPhone apps from the Education category. Shuler's study mainly examined quantitative variables such as age target and price, while he limited the qualitative review to the apps' marketing description, name, and marketing images. Goodwin and Highfield (2012) conducted a more targeted content analysis of 240 children's mobile apps with particular attention paid to mathematics learning apps. Their analysis took place over two years and was coded for only three variables: age, subject, and pedagogical approach. Handal, El-Khoury, Campbell, and Cavanagh (2013) reviewed 100 mathematics curriculum apps for children to identify genres or categories of learning apps. Watlington (2011) reviewed 100 free iPod Touch educational apps for developmental appropriateness and recommended only 48% for classroom use. Finally, for a more thorough content analysis, Richards, Stebbins, and Moellering (2013) reviewed 19 purposefully selected apps to illustrate various types of learning games in terms of genres and educational content.

Based on these studies, the present researcher decided this study's sample size would be 100 apps, allowing for a range of content and genres, but necessarily constraining the size of the study for qualitative content analysis.

3.2.3 Sample Selection

Given the large scope of the App Store Kids library, sampling procedures could become unwieldy and overwhelming. As a starting point for identifying eligible apps, the research referenced the January 2014 issue of *Children's Technology Review* for its "Top 107 Children's Apps" curated list.

Children's Technology Review (CTR), managed by educational technology researcher Warren Buckleitner, aims to provide "complete and objective reviews of children's interactive media products" (Children's Technology Review, 2013). Since 1985, CTR has published monthly reviews of children's digital content and products. Recently, CTR has turned its focus to children's mobile apps. CTR focuses on commercially available apps and tends to favor apps that offer children control over their experience and with a constructivist learning approach (see Chapter 2.6.1). The top apps list, published in January 2014, is intended to showcase the best examples of children's mobile apps currently on the market.

The top apps list by *Children's Technology Review* included a number of apps designed for a target audience whose age ranges outside of the present study's sampling criteria. Consequently, the researcher excluded 17 apps, leaving 90 apps. Three of the remaining apps required the purchase of a printed book alongside the apps. Since this current study was primarily interested in mobile apps rather than hybrid play experiences, it excluded these. In addition, the researcher observed the list included multiple versions of several games sharing similar design and game play but reproduced with different themes or "skins." To ensure that the sample represented a variety of offerings from the marketplace, the researcher included no more than 3 of a similarly "re-skinned" app. This left 79 apps on the list.

To replace removed items from this list, the researcher randomly selected 21 additional apps from the Kids category available as of March 15, 2014. The resulting 100 apps provided a sample of apps that represented the best and most popular set of mobile apps for children aged three to five.

A non-probabilistic *purposive sampling* method is intended to showcase exemplars of the present study's theoretical perspectives (Patton, 1990). While purposive sampling typically occurs through convenient samples or snowball samples, sampling procedures could derive from a particular set of criteria most relevant to the theoretical model being examined. As this study aimed to analyze a selection of app content best illustrating the affordances of the mobile apps landscape for promoting PTD, the use of an expert-curated list allowed this study to purposefully select an ideal body of content. The use of an expert to curate the sample made this a *judgment sample.*

3.3 Instruments

This study devised three instruments to analyze the content of the sampled mobile apps. One instrument was an evaluation form to assess the developmental appropriateness of the design of these apps. Two of the instruments are content survey forms intended to estimate the range and variability of content available on the App Store marketplace. Altogether, these three instruments reflect the three pillars of developmentally meaningful apps.

3.3.1 The Children's Apps Categorization Form

This short form sorts children's mobile apps into the three primary categories: game apps, interactive eBooks, and utilities. Each of these categories then subdivide into subcategories or genres as follows:

1. Game apps – Game apps include any interactive content that offers game play with an objective or purpose. The objectives or purpose may or may not relate to curriculum.

    A. Instructive – Curricular game play that take on drill-and-practice nature where questions are presented, often in multiple-choice manners or close-ended fashion, where correct answers would advance the player to proceed to the next question.

    B. Manipulables – Digital interactive learning tools that engage players in exploring and learning about a concept through experimentation and manipulation of purposefully designed digital artifacts.

    C. Puzzles – Games that challenge players cognitively, typically with progressively difficulty levels. These games have little to no narratives.

    D. Role-play – Character driven games in which the player experiences the narrative of a game or a series of activities by taking on a role in the game.

E. Simulations – Virtual experiences in which the player receives control over the environment to experiment and explore freely with a view to achieving objectives.

F. Casual – Simple activities with game objects that do not challenge players cognitively and typically lack correct/incorrect outcomes.

2. Interactive eBooks - Interactive eBooks go beyond a traditional eBook by offering features such as word-by-word highlights and interactive hotspots on each spread to engage the reader.

A. Read to Me – Offers basic interactions that when tapped reads the text of each spread to aloud.

B. Read & Play – A reading experience supplemented by game play or other interactive activities.

3. Utilities – Utilities are open-ended apps that do not have a particular game objective or narrative. They are useful tools to accomplish other tasks.

A. Creativity – Open canvas or creativity tools for manipulating photograph manipulation, recording videos, or creating animations.

B. Productivity – Tools to support other tasks such as a calendar, calculator, or stopwatch.

3.3.2 The Developmentally Appropriate App Design Evaluation Form

The present study takes guidance from the various developmentally appropriate design perspectives (see Chapter 2) and offers an amalgamated framework for developmentally appropriate design practices in mobile apps for preschool children. This framework includes five design principles as follows:

1. Interaction Design – Apps should use intuitive gestures and leverage visual cues rather than text to support players' interaction.
2. Visual Design – Apps should isolate hotspots from background and offer few distractions from game play. Visual design should enhance rather than burden players' attention.
3. Audio Design – Apps should use characters to guide gameplay. The use of a narrator is less desirable but better than its absence altogether. It should supplement audio with visual cues and consider the short attention span of young players.
4. Instructional Design – Apps should treat all players as new to the device and offer the appropriate level of guidance to help players learn the game mechanics.

As the researcher devised this form for the purpose of this present study and is the first time this form will be used, it is critical to evaluate the validity and reliability of this measure. The researcher will conduct validity analysis during the pilot phase by evaluating the correlation and predictive power of this form to an external source of credible usability and design ratings.

3.3.3 The Positive Technological Development for Young Children Form

The researcher devised this form to categorize children's apps based on their intended goal as pertaining to children's PTD. As such, the primary variables are the six Cs of PTD as the literature review described. These variables are operationalized by targeting specific developmental needs of preschool children aged three to five. An app can include content that address multiple areas of PTD.

1. Competence – Apps that scaffold the learner through his or her zone of proximal development with appropriate feedback loops to reward success and turn failure into teachable moments. Wherever possible, curriculum content should offer differentiation or individuation to address the learning needs of children.
2. Confidence – Apps that foster self-esteem and self-worth through the use of permanent badges or similar mechanics to reward players. In addition, apps should consider ways to offer an open canvas for players to create a portfolio of work to express themselves. To promote self-efficacy, apps should make available an on-demand or just-in-time help button to retrieve additional scaffolding and support.
3. Caring – Apps that facilitate caring relationships between individuals. Apps should encourage children to play and cooperate together. Multi-player digital experiences should consider design attributes including timing (asynchronous vs. synchronous), scope (pair vs. group play), nature (collaborate vs. competitive play), and social dimension (parallel, associative, or cooperative play).
4. Connection – Apps that leverage technologies to connect players with different members of their social network while keeping in mind

privacy and safety features that make social networking developmentally appropriate for children.

5. Character – Apps that engage children in learning about and making moral decisions with positive modeling, thought experimentations, and exploring choices and consequences in a safe but authentic space.

6. Contribution – Apps that empower children to contribute to other people's projects in the form of sharing and helping others through technology. These pro-social behaviors could be simulated or virtually enacted within digital world, or technology could mediate such behaviors in the real world.

3.4 Validity and Reliability Measures

3.4.1 Validity of the Developmentally Appropriate App Design Form

As a newly devised evaluation form for this study, it was important to first assess the validity of the *Developmentally Appropriate App Design* evaluation form before any further analysis. To that end, the researcher assessed concurrent criterion validity by comparing results from this form against published usability ratings of these children's apps.

Concurrent criterion validity involves the comparing of one measurement against a criterion variable taken as representative of the underlying construct. Because the notion of developmentally appropriate app design is new to the field of children's technology, there are no existing measurements precisely describing the variables in the present study. To approximate, the present study references

Children's Technology Review for their *ease of use* (EoU) ratings of various children's mobile apps.

Within the study's sample, *Children's Technology Review* (CTR) reviewed 87 apps with an EoU rating. From this sub-sample, the researcher randomly selected 30 for validity evaluation. The researcher reviewed these using the *Developmentally Appropriate App Design* evaluation form and compared their evaluation results against their relevant ratings from CTR using correlation and regression analysis.

The researcher compared the four app design variables to CTR's EoU ratings. The category of Interaction Design significantly and strongly related to EoU, r (30) = 0.49, $p < 0.01$. Similarly, Visual Design also significantly and strongly related to EoU, r (30) = 0.56, $p < 0.001$. Instructional Design moderately related to EoU, r (30) = 0.39, $p < 0.05$. Finally, Audio Design resulted in a trend correlation with EoU, r (30) = 0.35, $p = 0.057$.

The researcher inputted these four variables into a regression analysis to assess their predictor value to CTR's EoU rating. Results showed that these four variables, in aggregate, accounted for a significant amount of variance in EoU, R^2 = 0.44, F (4, 25) = 4.97, $p < 0.01$. Of the four variables, Visual Design ($t = 2.872$, $p < 0.01$) appeared to contribute most to the model. Given these four app design variables significantly related to the EoU rating, the researcher computed an aggregate App Design score as a sum score of these four variables. The aggregate App Design score significantly and strongly related to CTR's EoU rating, r (30) = 0.54, $p < 0.01$.

Based on this criterion validity analysis, the four design domains of the Developmentally Appropriate App Design evaluation form seemed to be valid and reliable measures of developmentally appropriate design as they relate to usability. As such, the present study continued to use this form for the entire sample of 100 apps.

3.4.2 Inter-rater reliability

The researcher assessed inter-rater reliability of the study instruments and the study procedure by comparing the rating results of two researchers who completed the review forms on the same sample of content as the validity assessment in Section 3.4.1. Inter-rater reliability provides an estimate of the consistency or the degree of agreement among researchers using the same measurement. For any given measurement that includes subjective evaluation or assessment, a high inter-rater reliability suggests observer bias is less likely to affect the measurement.

Two researchers reviewed the 30 apps independently. By comparing the two datasets, the two researchers achieved a joint probability of agreement of 0.94, or 94%.

3.5 Procedures

Once all of the instruments had been evaluated for reliability, the primary researcher analyzed the full sample by following the following procedures:

1. The researcher downloaded the sample of children's apps onto a single device.

2. On one particular day, the researcher collected all publicly available statistics, including download frequencies, user ratings, and blog review ratings for all the apps in the sample.
3. The researcher played each app until reaching content completion.
4. Researcher completed the three mobile apps evaluation forms.

3.6 Research Permission and Ethical Considerations

Because no human participants were involved, this study did not obtain IRB approval or content procedures. Given that all eligible apps were publicly available on the Apple's virtual marketplace *App Store*, the study did not use pseudonyms in the analysis.

Chapter Four: Findings

A virtue of gaming that is sometimes overlooked by those seeking grander goals…is its unparalleled advantages in training and educational programs. A game can easily be made fascinating enough to put over the dullest facts. To sit down and play through a game is to be convinced as by no argument, however persuasively presented.

-A. M. Mood and R. D. Specht, *Gaming as a Technique of Analysis*, 1954.

The following sections present the results of the content analysis. The first section will provide an overview of the general landscape of children's iOS apps, including an estimated distribution of genres and content types. The second section examines the developmental appropriateness of these apps and offers a discussion of specific design techniques commonly used to support the developmental needs of children. The third section includes an analysis of children's apps as they relate to each of the six areas of PTD. Throughout this chapter, numerous vignettes are included to illustrate how content creators address the developmental needs of young children using mobile technology.

4.1 Content

The researcher coded app content into three non-exclusive categories: game apps, interactive eBooks, and utilities. Results showed limited variability in the distribution of these apps. Of the 100 apps, 73% were game apps, 28% were interactive eBooks, and 13% were utilities.

Of these categories, only interactive eBooks cross-categorized with others. There were 28 interactive eBooks, within which 11 (39%) included learning activities or game play, two (7.1%) included activities to create art or drawings, and one (3.5%) included a utility to support the overall lesson of the eBook. The remaining 14 (50%) did not include any features beyond the eBook and basic clickable interactive elements on each spread.

4.1.1 Content Domains

The researcher categorized all 100 apps into 12 content domains. Ten categories related to skills or curriculum, one just for fun category, and an *others* category for content related to a topic not captured by these domains. These categories were not exclusive; so one app could include content from various domains of learning and development. Results showed that these 100 apps clustered around two primary topics: literacy (n = 40) and mathematics (n = 20). This was followed by a group of apps focusing on general cognitive skills such as matching, sorting, and memory skills (n = 18). Content related to other learning domains were rare. See Figure 4 for a summary of content distribution. Although an integrated curriculum that leverages a content theme to teach multiple subject domains is more appropriate for young children (Hart, Burts, & Charlesworth, 1997), only 18 (18%) apps offered mixed curricula or content areas.

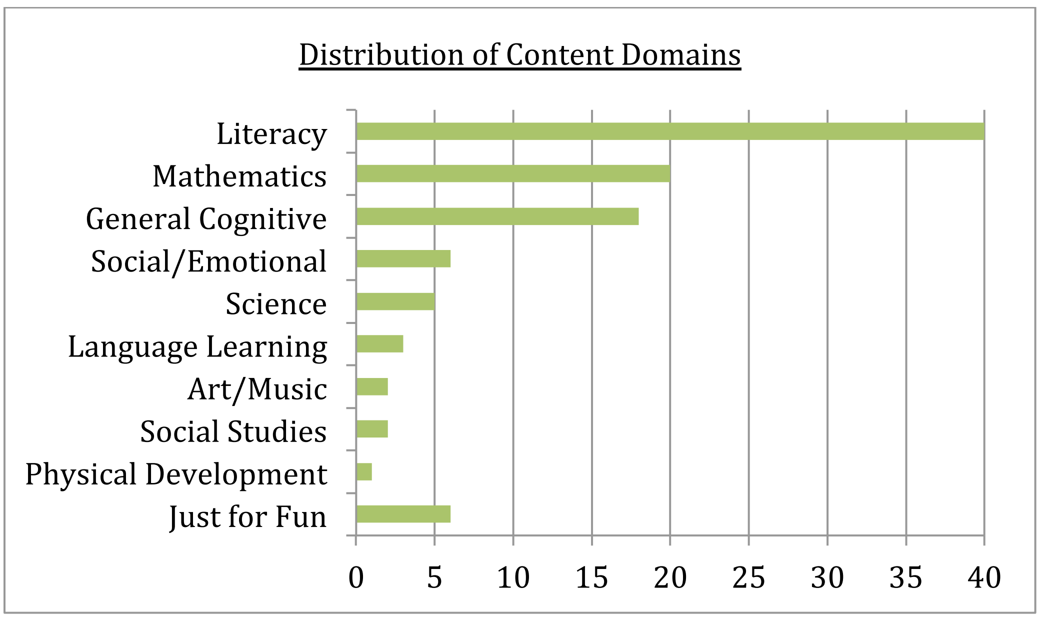


Figure 4. Distribution of content domains

4.1.2 Game Apps

The 73 game apps fell into six categories: instructive, manipulable, puzzles, role play, simulations, and casual games. Results showed that these apps tended to favor the instructive type of drill-and-practice academic exercises (n = 31, 42.5%), followed by casual games that had little to no narrative to complement repetitive non-curricular activities (n = 11, 15.1%). There were just about the same number of manipulable apps (n = 10, 13.7%), puzzles (n = 10, 13.7%), and role-play games (n = 9, 12.3%). Finally, there were only an anecdotal two simulations (2.7%). The differences across these categories were significant, χ^2 (5) = 39.28, $p < 0.001$.

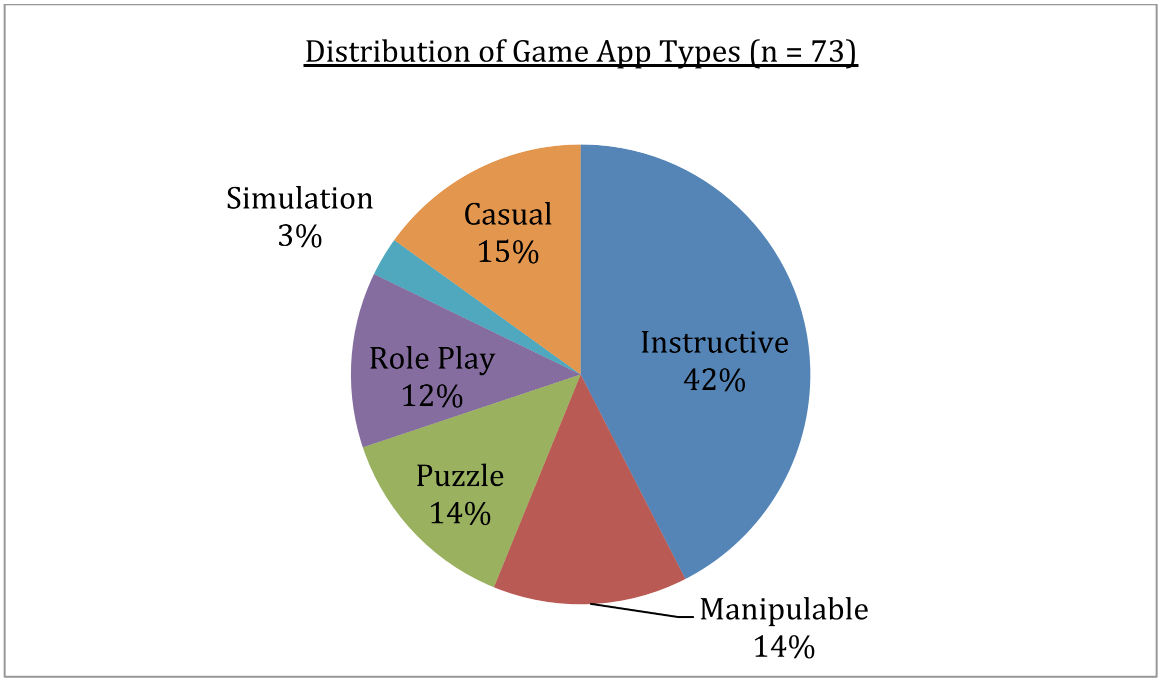


Figure 5. Distribution of game app types (n = 73)

The most common of all game apps was drill-and-practice instructive apps that typically focused on one or two traditional curricular subjects such as literacy (n = 17) and early mathematics (n = 11). These apps repeatedly presented players with multiple-choice questions to answer. These apps tend to only assess players' knowledge rather than teach new concepts. Often, players who were challenged by the content would only learn through trial-and-error, or not at all, when they exhausted all possible answer choices. Instructive apps tended to have the least amount of game narrative, often trivial or unrelated to the curriculum. **Vignette 1** describes the app *Mathtopia+* as an example of a typical Instructive app.

Manipulable apps were another popular group with a focus on academic curriculum. While they still revolved around answering questions, these apps presented players with a digital tool or artifact to explore curricular concepts in ways similar to a classroom mathematics or science manipulative. However, many of these apps did not provide explicit instructions and therefore players had to rely on external learning opportunities to learn new concepts. As such, manipulables tended to assume that they supplemented learning, rather than being used as primary educational opportunities. These apps often took on a Montessori teaching methodology both in design and in name. For example, three of these apps used the term *Montessori* in their title. Through personal communication (*Les Trois Elles,* personal communication, February 11, 2014), the researcher learned that the creators of these apps did not represent any Montessori organizations other than having received training and certification in the Montessori teaching methodology. Vignette 2 describes an example of a typical manipulable app.

Puzzle apps were primarily virtual or digital versions of common children's puzzles such as mazes, matching cards, or jigsaw puzzles. These were less academic but focused more on general cognitive skills. In some ways, these were quite appropriate given preschool children's developing logic and reasoning skills. Unlike the previous game categories and as an enhancement over traditional tabletop puzzles, many puzzle apps wrapped play within a larger narrative, giving meaning and context to the otherwise repetitive activities. Puzzle apps tended to include multiple puzzle types within one app to vary the experience. Vignette 3 describes *Curious George Curious about Shapes and Colors* as an example of a narrative driven puzzle app.

Role-play apps adopted a genre common to traditional video games. These apps cast the player into the game through either a first-person view (where the player navigated an environment) or a third-person view (where the player controlled an on-screen character). Role-play games offered learning and play experiences contextualized in a narrative. They gave meaning and reason to gameplay actions and to the curriculum. These apps provided a great opportunity for players to learn life skills such as daily routines (n = 3), exercise social-emotional skills such as self-regulation and self-monitoring (n = 1), explore science concepts (n = 1), and practice language skills (n = 2). Vignette 4 describes *Dr. Panda Home* as an example of a role-play game teaching children about life skills related to the home.

Simulation apps were celebrated as an important affordance of the digital platform offering players safe and consequence-free virtual environments to explore new concepts, practice new skills, and experiment with decisions. However, results showed that there were very few examples of such apps (n = 2). Simulation apps tended to have little to no objectives and players were left figuring out how to play the game and the meaning of their activities. The simulation apps in the sample were ideal for exploration and free-play, but did not seem to provide any sort of instructional or developmental benefits other than entertainment and enjoyment. Vignette 5 describes *Toca Cars* as an example of a simulation app for young children.

There were more casual apps than expected among the sample of children's mobile apps (n = 11). These tended to have little to no educational or developmental values other than entertainment and whimsy. They were repetitive but simple activities that resulted in fun payoff, and were meant appeal to young players. Vignette 6 describes one particular mini-game from *Mo On the Go*, a fun, humorous activity that offers limited educational value.

4.1.3 Interactive eBooks

The 28 interactive eBooks presented an interesting category of children's mobile apps. For one, interactive picture books were unique to the children's market. The interactive eBooks in the sample shared many similar characteristics, such as word-by-word highlights as the narration spoke, an ability to turn on and off the narration, and interactive clickable hotspots on each spread to engage the child reader. Slightly less than half of the eBooks (n = 13, 46.4%) fell into the Read to Me category that offered only these basic features. The remaining (n = 15, 53.6%) consisted of Read and Play eBooks that included additional games or creativity components to augment the value and experience. Altogether, these various features created an enhanced reading experience beyond what a traditional book could offer.

Of the 15 Read and Play eBooks, the researchers found two major types. Eleven (73.3%) of these eBooks integrated small game activities within the narrative that tied to the plot. Vignette 7 describes one such eBook, *Chuggington Chug Patrol*. By integrating game play in this way, the activities stimulated reading and listening comprehension. The remaining four (26.6%) included additional activities, such as jigsaw puzzles of character images and graphic spreads outside of the reading component as separate mini-games that enhanced the experience and engagement of the reader. These add-on activities seemed less integral to the overall comprehension of the narrative.

4.1.4 Utility Apps

Thirteen (13%) of the sampled apps fell into this last category of utility apps. These are open-ended applications lacking any narrative, game play, or specific teaching goals. Within this set, 10 (76.9%) were creativity apps that offered children a blank canvas for artistic expression. Creativity apps were not limited to art and drawing activities (n = 6), though these tended to be a focus. To a lesser extent, creativity apps also covered topics such as music (n = 1), simple animations (n = 2), storytelling (n = 1), and game design for children (n = 1).

The remaining three (23.1%) apps in this category were single-functioned productivity utility software, including an innovative calculator that could detect handwriting, a child-friendly and child-safe email program, and a timer designed to help children calm down. Vignette 8 describes an example of a utility app, Maily, that offers young children a safe, secure, and developmentally appropriate way to explore the concept of email.

Vignette 1. Mathtopia+

Target Age: 5+
Price: $3.99
Design Scores:

Interaction	7
Visual	4
Audio	0
Instruction	2

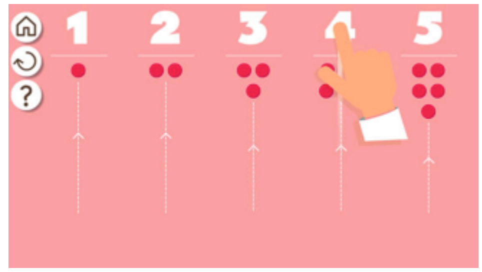
As an Instructive app, *Mathtopia+* emphasizes drill and practice with early mathematical operations. Players are presented with a screen full of simple equations and must tap the corresponding answer to the right. When three adjacent circles are correctly answered, they disappear in a *Match-3* game fashion. The game play does not relate to the mathematical concepts being practiced. In some way, the curriculum is in a sense an obstacle to get past to play the game, and reflects poorly on the general sense of using game play to enhance the learning experience.

The app does not provide any audio instructions and must rely on players or adults reading text instructions, labels, and menus. The game uses sound effects and slight animations as feedback for correct or incorrect answer input. Unfortunately, the app does not "teach" mathematical concepts; it purely assesses. In the specific example illustrated in the screenshot, if a player does not know how to answer "1+2," the player may, through trial and error, eventually learn to match that circle with the numeral 2 to the right. However, the player would never learn the underlying principles of addition.

Vignette 2. Montessori Math: 1st Operations

Target Age: 5+
Price: $3.99
Design Scores:

Interaction	3
Visual	4
Audio	3
Instruction	3



As a Manipulabe app, *Montessori Math: 1st Operations* offers players virtual mathematics manipulatives similar to those found in the classroom as they are challenged with series of early mathematical questions. For example, it uses *counters* to teach the one-to-one correspondence and cardinality rules. When the app presents the player with a mathematics question, players can use the virtual manipulatives to test out their answers before finally choosing the final answer. This app's design follows a *Montessori* teaching methodology.

This app provides great visual and graphical player support, such as the use of a hand to teach players how to operate the various features. However, in other places, it relies on text on screen, rather than, graphics, to show overall mathematical concepts and procedures.

One thing worth noting is the detailed and flexible parents menu that allows parents to set the app to 11 different languages, set the range of curriculum presented to the player, as well as the type of hints and supports offered when the player needs extra scaffolding.

Vignette 3. Curious George Curious about Shapes and Colors

Target Age: 2+
Price: $4.99
Design Scores:

Interaction	4
Visual	4
Audio	4
Instruction	3

Curious George Curious about Shapes and Colors is a puzzle game that is set in a light and brief narrative. Curious George has brand new toys in his toy box, but his toys seem to be broken in different ways. Using basic logic skills such as matching and sorting, the player fixes each toy after which the player is rewarded with a just-for-fun game such as navigating a toy robot or a toy train.

This app is one of the few apps in the sample that included an omnipresent on-screen character, *The Man with the Yellow Hat* to deliver instructions, question prompts, and scaffold. He lives in the upper right hand corner of the screen. Tapping on him will repeat the question or activity prompt the player is tasked to complete. Curious George lives on the lower right corner and adds a familiar face and relatable dimension to the app. However, his presence is purely aesthetic, as he does not have any function.

The game has limited content depth. Each toy requires the child to complete four to five very simple puzzle based mini-games. Altogether, there are about 30 quick activities. Each activity takes about 10-20 seconds to complete, just enough to hold a child's attention. Once completed, players can start on any toy again but the content would be identical to the first time the game is played.

Vignette 4. Dr. Panda Home

Target Age: 2+
Price: $2.99
Design Scores:

Interaction	3
Visual	3
Audio	0
Instruction	1

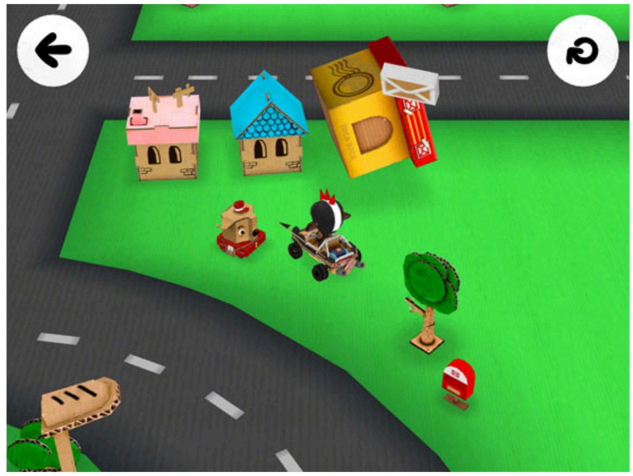
Dr. Panda Home is a set of mini-games with appealing graphics teaching daily life skills. Dr. Panda's home is full of various animal characters, each needing help completing their task for the day. There are over 20 different chores to complete. However, players are only presented with a set of three at a time. To know what chores are needed to complete, players tap on a chore chart menu that shows three chore icons. The choice of chores depends on whether it's morning, afternoon, or nighttime. During the day, players might be asked to clean the bathroom, mow the lawn, or look for a missing key. At night, chores might include taking a bath, picking up toys in the bedroom, and setting the alarm clock.

These mini-activities are typically very simple, requiring one to two quick gestures. A few activities are more elaborate and require basic cognitive skills such as sorting items by color and matching items to their location. Each day and each night present the player with a different set of chores.

The daily chore cart helps players understand game progression and serves as an interactive menu to quickly transition to incomplete tasks. Players could also swipe the screen to see different parts of the house to look for undone chores to complete. Completing each set of three chores reward the players with a gold coin that can be saved to the piggy bank. The game includes a toy store where gold coins can be exchanged for toys of different values. Toys serve as trophies with no other interactive function.

Although Dr. Panda Home does not include any narrator dialogue, the game revolves around helping various animal characters complete their chores. On-screen characters offer visual and auditory feedback through sound effects when players successfully or unsuccessfully complete a task. The use of visual flourishes such as sparkles and color highlights help players understand the game mechanic without explicit narrator dialogue.

Vignette 5. Toca Cars



Target Age: 3+
Price: $2.99
Design Scores:

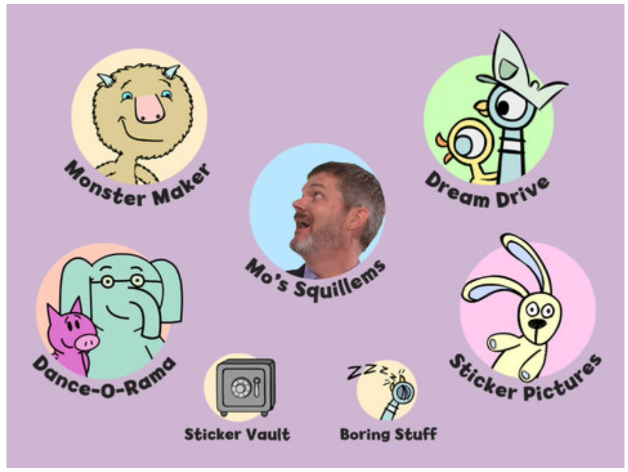
Interaction	3
Visual	4
Audio	0
Instruction	0

Toca Cars is an exploratory simulation game where players can build their own town to drive around for fun. Players are offered two modes to play. In the play mode, players are presented with pre-generated town full of buildings, animals, nature elements, roads, and traffic lights. The art is presented to emulate cardboard constructions. As its marketing description implies, "No rules apply to these roads." Using a single touch, press-and-hold mechanic, players can drive around the town with no concerns for the actual town. Players can drive through buildings, knock down trees, and even run into animals. There are also inclines and platforms to launch stunts and jumps.

In the Editor mode, players can design and construct their own town by populating the town with various elements, including road signs, buildings, platforms, and even animals. The user interface is well-designed and simple to use. Instead of complicated menu hierarchies, *Toca Cars* presents players with a single scrollable list of items to drag onto the screen. Choices are limited but not overwhelming. Once the town complete, players can drive around in the town that they have created in similar fashion as the play mode. The game also offers a "Restore" button to reset the town after it has been destroyed.

Although *Toca Cars* offer a worry-free "digital toy" experience, it lacks much education or developmental value. For one, the underlying message of driving a car through the town without any rules or consequence is questionable. Regardless of one's interpretation of its educational value, this app also misses many opportunities for teaching and learning. For example, the game includes working traffic signal lights, albeit made of cardboard. Because *Toca Cars* opts for a no-rule game narrative, it misses an opportunity to teach about how traffic lights direct traffic.

Vignette 6. Mo… on the Go



Target Age: 4+
Price: $3.99
Design Scores:

Interaction	4
Visual	4
Audio	3
Instruction	3

A whimsical, humorous app, *Mo…On the Go* is a set of five activities based on characters from Mo Willem's children's books. Using children's voice as an unseen narrator, the game directs players through these activities with simple instructions and simple mechanics. In *Monster Maker*, for example, players simply drag an on screen switch to mix monster parts randomly to create a monster. Once created, the monster animates briefly. In *Sticker Picture*, a simple creativity activity, players can take a photograph using the device's camera and add stickers to the photograph.

At the end of each activity, players are awarded a random sticker to add to the sticker vault. Players can collect up to 60 stickers. Collected stickers are available for use in *Sticker Picture*.

Mo…On the Go is not void of text icons and captions. However, it also uses many different narrator voices to announce instructions, narrative, and labels for buttons. Subtle animations such as character idle movements also draw the players' attention to game activities and interaction mechanics. Despite the humor and fun that this app offers, it lacks a cohesive narrative that ties the five activities together, and falls short of offering identifiable educational or developmental values. Nonetheless, this app makes a developmentally appropriate pastime.

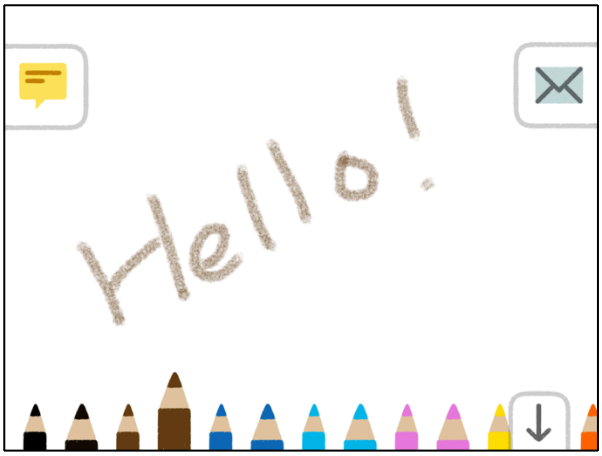
Vignette 7. Chug Patrol: Ready to Rescue

Target Age: 3+
Price: $4.99
Design Scores:

Interaction	3
Visual	4
Audio	3
Instruction	3

Chug Patrol: Ready to Rescue is an interactive pop-up book that tells the story of an episode from the popular children's television show. This eBook app offers three reading modes: Read to Me; Read it Myself; and Auto-play. The story revolves around the train characters traveling along a rail and encountering numerous obstacles along the way. The narrative lends itself to integrated game play. At every few spreads, the train characters encounter an obstacle, such as fallen trees on the rail. The eBook then turns into a game screen where players complete game tasks using simple gestures, such as tapping on fallen trees to remove them. Other game activities might involve more cognitive or academic challenges, such as color identification (e.g. catch the red cars). The general plots of these game activities relate to the narrative of the eBook and therefore they facilitate the players' listening and comprehension. In this way these game activities, albeit sometimes simplistic, are meaningful to the overall reading experience, rather than unrelated feature bells and whistles.

Vignette 8. Maily



Target Age: 3+
Price: Free
Design Scores:

Interaction	3
Visual	4
Audio	0
Instruction	0

Advertised as "Your Kids' First Email," *Maily* is a safe messaging platform for kids to send messages with friends and families within a protected network. To protect children's safety, parents must set up an account in the app and add child users to their account. From there, children can send messages to their parent (or the host of the parent account) or other children users on that profile using a simple-to-use drawing canvas. In addition to users of the same iPad device, parents can also add other *Maily* users to a contact book. All contacts must be added in the parent mode.

A unique feature to *Maily* is the parent's activity stream. Parents can adjust a setting to receive a copy of all messages sent or received by the children under that parent profile. This allows parents to monitor their children's messaging activities. Furthermore, for added security, parents can adjust a setting to require all incoming or outgoing messages to be stored in a queue for approval before they are received or sent to the recipient.

Maily's multi-level security measures and its easy to use interface make it a developmentally appropriate introduction to email messaging.

4.2 Design

The researcher used the results from the Developmentally Appropriate App Design evaluation form to estimate the extent to which these mobile apps applied developmentally appropriate design practices that accommodated the needs of preschool children. Overall, the 100 apps in the sample scored a moderate aggregate app design rating score, with a mean score of 8.91 (*SD* = 2.50) points out of a total of 16 points across the four categories of interaction design, visual design, audio design, and instructional design.

4.2.1 Interaction Design

Interaction design was similar across the 100 apps in the sample, with a mean score of 2.88 out of 4 points (*SD* = 0.86). Almost all (n = 99, 99%) of the apps received a score of 2 or higher. The majority of apps (n = 89) adhered to best user control practices as laid out by Sesame Workshop's recommendations, favoring simpler input gestures such as tap, swipe, and drag. Nine other apps used a variety of gestures that were less appropriate, such as tilt and flick. Finally, two apps used complex gestures such as multi-touch and pinch that could be difficult for young children. Mostly, the apps in the sample represented preferred user input mechanics, χ^2 (2) = 140.18, $p <$ 0.001.

The other two aspects of interaction design were less desirable, and app creators did not seem to adhere to a particular practice. Only 42 apps used highlights or other graphical mechanics to draw attention to user interface, χ^2 (1) = 2.56, *ns*. Similarly, only 59 apps avoided the use of text labels on icons and buttons and used easy-to-interpret or commonly recognizable graphics for user interface. This meant 41 of the apps, including those intended to teach basic reading skills and letter recognition, used text labels that might not be comprehensible by pre-readers, χ^2 (1) = 3.24, *ns*.

4.2.2 Visual Design

In terms of visual design, these 100 apps scored a relatively high average of 3.61 (*SD* = 0.75) out of 4 points. Ninety-seven apps received a score of 2 or higher. The visual design scale consisted of four dichotomous components. Of these apps, 80% of the apps used visual mechanics to highlight interactive "hotspots" on the screen to guide the child's interaction, χ^2 (1) = 34.82, $p < 0.001$. Similarly, 87% presented icons and buttons against a simple background to help players attune to game play interactions, χ^2 (1) = 53.3, $p < 0.001$. As recommended by Sesame Workshop, 97% presented content in typical scan directionality (left-to-right and top-to-bottom), χ^2 (1) = 86.5, $p < 0.001$. Finally, almost all but one (99%) presented a consistent visual design language throughout the entire app.

The four visual design items on the scale related to the extent to which an app used visual design techniques to scaffold the young player's interaction. In the sample, the researcher observed several visual design techniques that helped draw the player's attention to key icons and buttons on the screen. One common technique was the Heads-Up Display (HUD) or menu bar that separated interactive elements from the background. In the example of *Daniel Tiger's Day & Night* (Figure 6), the vertical menu bar separated interactive elements from the general background image. In contrast, a game in the interactive eBook, *The Pirate Princess* (Figure 7), presented player with a screen that integrated interactive elements within the scene. On this screen, the player had to choose a costume for the princess to wear. Without a clear delineation between interactive elements (i.e. answer choices) from the background, the player had to explore the scene by tapping or dragging various items to see which of them were interactive and relevant to the question asked. This type of design technique seemed to encourage more exploration but could potentially frustrate a player who could not find the correct item among the numerous elements in the background.

Figure 6. *Daniel Tiger's Day & Night*: A menu of buttons to direct interaction.

Figure 7. *The Pirate Princess*: Hotspots confusingly integrated into the scene.

4.2.3 Audio Design

The use of sound and audio can help guide the young player's interaction with an app. The audio design component of the evaluation scale focused on the use of characters to introduce game play and instructions and facilitate coherence between instruction dialogue, visual cues, and animations.

Overall, the apps in the sample received a low audio design rating, with a mean of 1.20 points (SD = 1.19) out of 4 points. Thirty-nine (39%) of the apps received a score of 2 or higher, χ^2 (1) = 4.42, $p < 0.05$. The low score was largely attributed to the lack of dialogue in many apps. Of the 100 apps, 42% did not implement any character or narrator dialogue for instructions, prompts, or game narrative, χ^2 (1) = 2.26, *ns*. Instead, they used text, animations, and highlights to guide player interaction. Forty-four percent of the apps used a narrator to deliver instruction dialogue and prompts. Although recommended by best design practices, only 14% of the apps included an on-screen game character to deliver dialogue. The difference between using an on-screen character and a hidden narrative to deliver instructions was significant, χ^2 (1) = 14.5, $p < 0.001$.

The researcher found that the use of an on-screen character to deliver game dialogue was more effective in drawing attention and made dialogue more meaningful and relatable. In the example of *Curious George: Curious About Shapes and Colors* (Figure 8), The Man with the Yellow Hat always appeared at the top right corner of the screen and delivered all game instructions and dialogue, including question prompts, reward dialogue, and curricular scaffolding. Although this technique had good potential as a design approach, the sampled apps rarely used it.

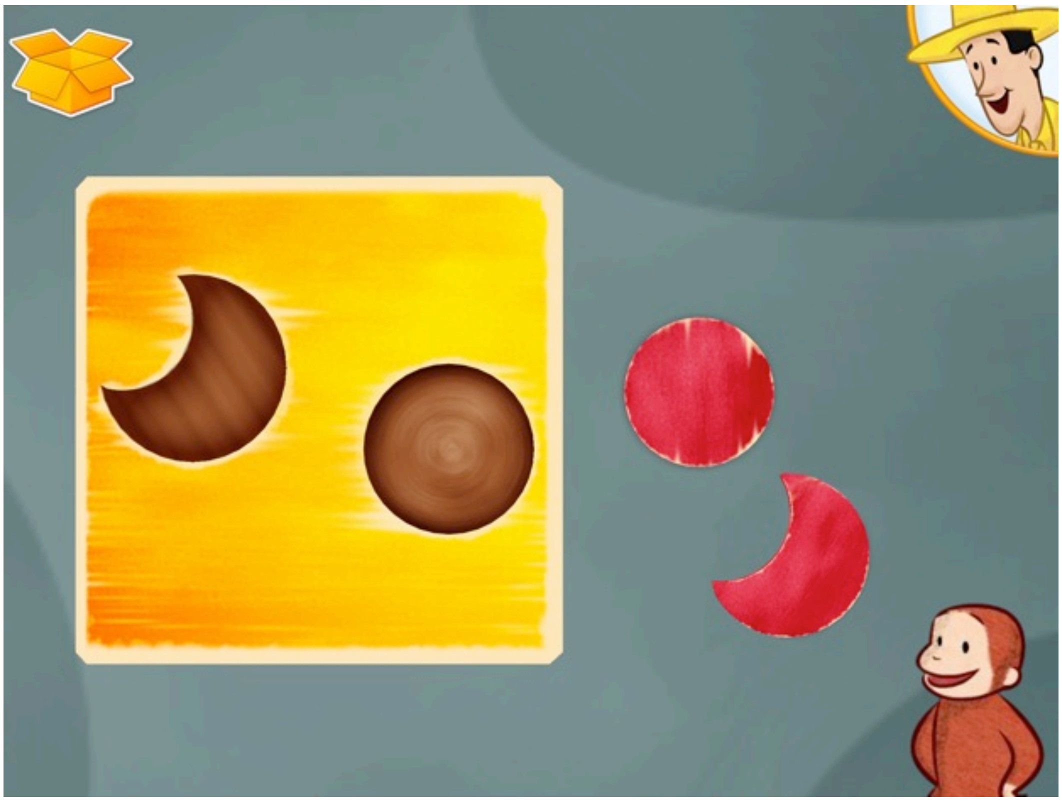


Figure 8. *Curious George*: The *Man with the Yellow Hat* guides all interactions.

4.2.4 Instructional Design

Designing content for preschoolers is particularly challenging given that they are pre-readers; thus, app designers cannot rely on text instructions to guide game play. Yet, these 100 apps received a very low score for their instructional design, with a mean of 1.21 (SD = 1.05) out of 4 points. Forty-four (44%) of the apps received a score of 2 or higher, χ^2 (1) = 1.21, *ns*. The researcher attributed this low score to the lack of design attention paid to game play instructions. Of these apps, 43% did not offer players any instructions on how to play or operate the app, χ^2 (1) = 1.69, *ns*.

In some cases, this was understandable as the design of the game included graphical and visual elements to isolate and guide the player's interaction. For example, in *Sago Mini's Bug Builder*, the app presented players with minimal content on the screen (see Figure 9). With little distraction, the player could surmise the interaction mechanics and the game objective. In contrast, an otherwise well-designed app with a depth of content could be hindered by the lack of interaction prompts, dialogue, or instructional scaffolding. In *Human Body*, the player saw with various views of the human body (see Figure 10). Tapping the screen would sometimes trigger animation or sound effects; other times a tap or a touch on what appeared to be a hotspot would note result in a response. Without any dialogue or prompts, the player could be left wandering and aimlessly searching for interaction through trial and error. Although the app contained a depth of curriculum, it missed the opportunity to actively teach about the human body because of its lack of dialogue or instructional prompts.

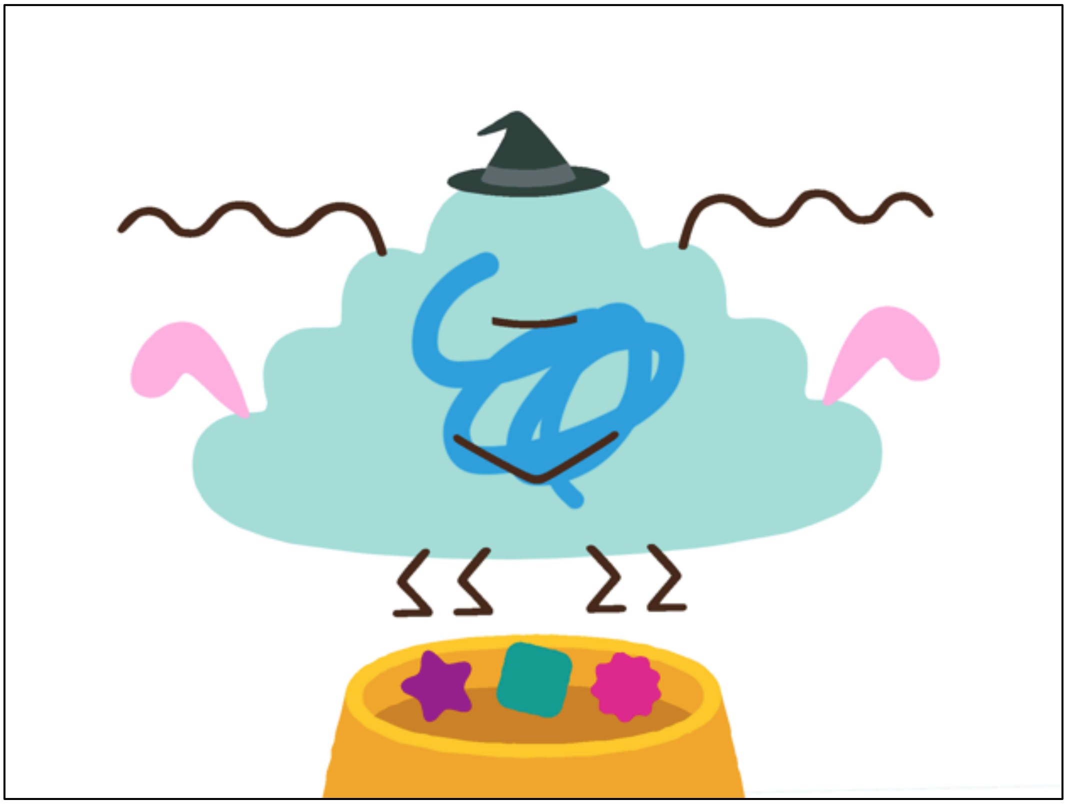


Figure 9. *Sago Mini Bug Builder*: Unclutter screen with only relevant graphics.

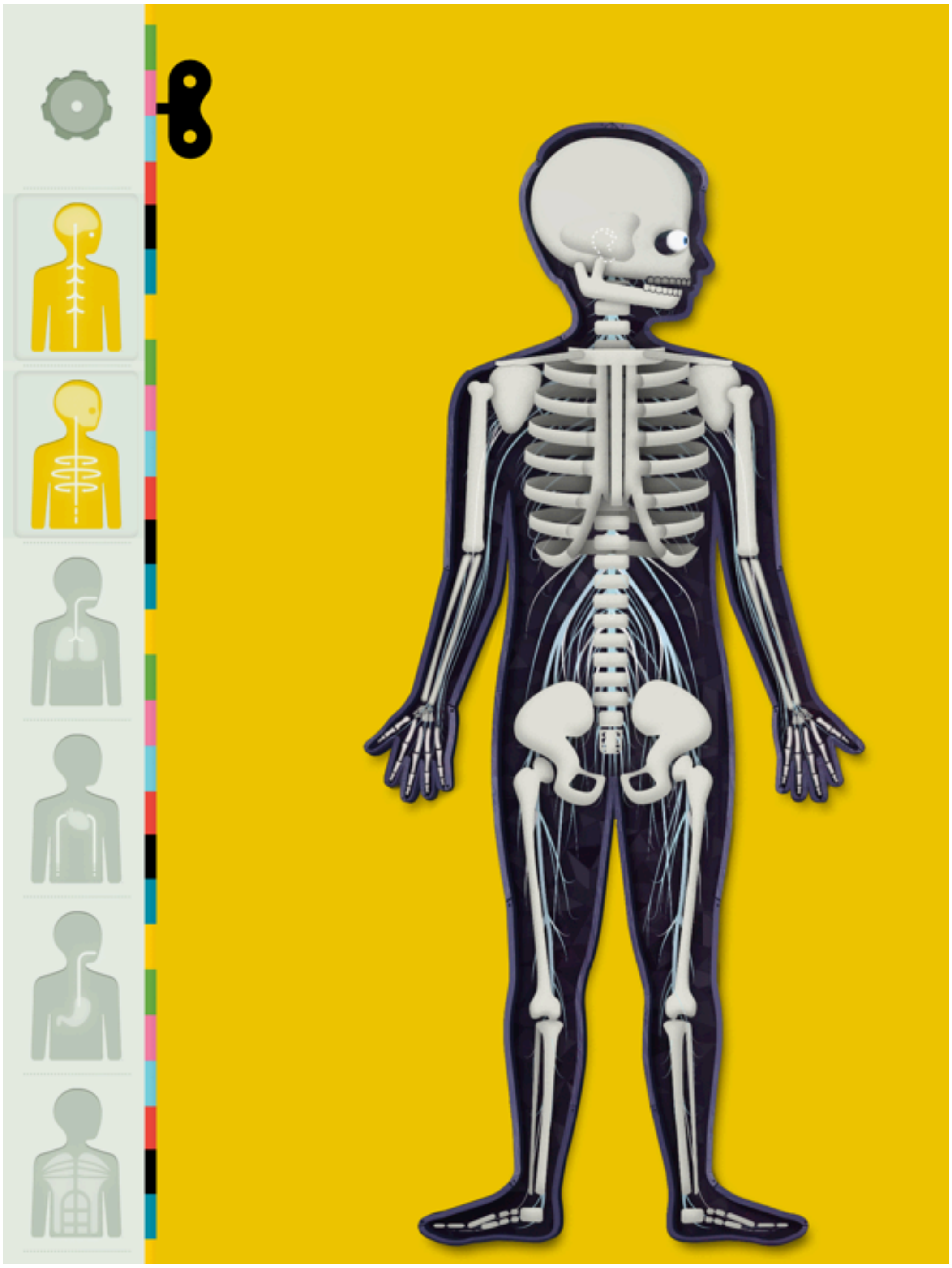


Figure 10. *The Human Body*: Lack of dialogue compromises active teaching.

Even when instructions were offered, they were not always designed well for young players. Although these apps targeted a pre-reading audience, 10 of the apps offered only text instructions, even when some of these apps taught basic reading and vocabulary skills. For example, adhering to a recommended practice, *ABC Farm* (Figure 11) offered a persistent help button on screen for the young player. Although the app introduced basic letter recognition and vocabulary skills, the help button brought up text information that overlays the screen. To an extent, the use of text-only instructions rendered the instructions meaningless to young players unless supervised by an adult. About 50 of the apps offered only audio instruction prompts (n = 19) and another quarter offered only graphics instructions (n = 25). These were more comprehensible to young players than text instructions and the researcher considered them to be quite effective in guiding the play experience. Finally, only a small selection of apps (n = 3) offered step-by-step visual and audio instructions to guide the player. Vignette 9 describes the app *Addimal Adventure* that incorporated clear interaction design, visual design, audio design, and on-screen characters to create a systematic How-To-Play tutorial effectively teaching the player how to play the game as well as curricular concepts. Although this technique was most effective, it was rarely employed.

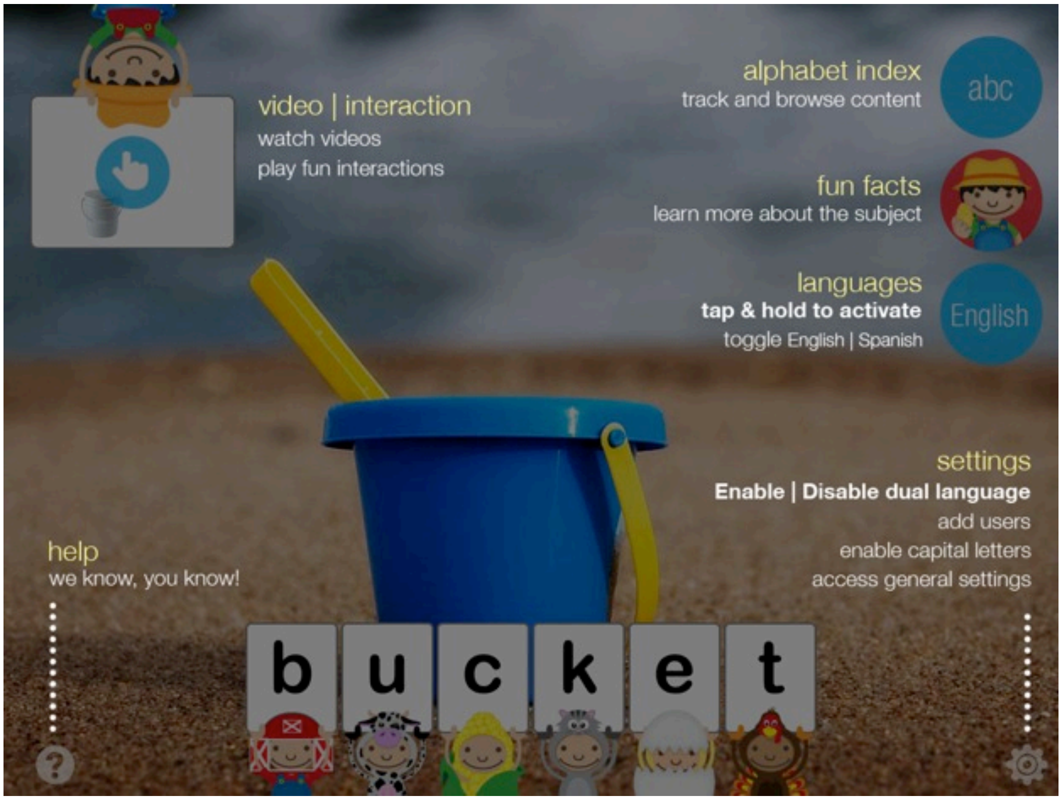
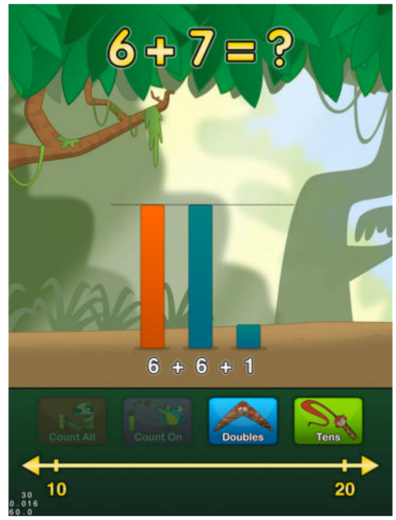


Figure 11. *ABC Farm*: Help button shows text-only instructions.

Vignette 9. Addimal Adventures



Target Age: 5+
Price: Free
Design Scores:

Interaction	4
Visual	4
Audio	3
Instruction	4

In *Addimal Adventures*, players are asked to help a team of animals save the golden city of El Sumado from Professor Possum who is set to destroy the city. To save the city, players must complete a series of basic addition questions. Each animal represents and uses a different addition strategy (counting, counting on, near double, etc.). At each addition question, players have to choose a strategy, which then guides the child to complete the question. Players start out with basic counting strategies. As they progress, new animals join the game to teach new addition strategies. Therefore, as players progress, they have more choices in how they want to answer each question.

As an overtly teaching and instruction app, *Addimal Adventures* includes a number of interactive tutorials narrated by the in-game animals. When each strategy is introduced, the screen cuts away to an interactive activity where the representative animal talks the players through the steps to add two single digit numbers using a particular strategy.

Given the limited dataset from 0+0 to 10+10, the app presents parents with a report of of correct/incorrect answer attempts to every added pairing. So, parents can keep track of which addition problems their children find challenging. In addition, the parent's portal offers tips and information about the skills being taught in this app. Advertising materials online for this app align the content of this app to specific Common Core standards.

4.3 Dynamics

The content analysis of the 100 apps showed that children's mobile apps cover a wide range of curricular subjects and game genres. Not only do children's apps need to be developmentally appropriate, they also need to engage children in activities and behaviors that stimulate optimal development. The following section examines the extent to which these apps offered content that could promote optimal development as defined by the PTD framework (Bers, 2012).

4.3.1 Mobile Apps for Building Competence

According to PTD, to build competence, apps must offer activities promoting the development of skills and knowledge. Specifically, competence apps involved some sort of demonstration, instruction, or teaching. This category did not include utilities apps or just for fun content. Results showed that a large portion of the apps in the sample addressed this domain of PTD (n = 78, 78%, χ^2 (1) = 34.26, $p < 0.001$).

As discussed in Chapter 2, designers can leverage digital technologies to provide learners with dynamic feedback and content progression. Scaffolding could take the form of question and answer feedback loops and content progression or leveling. Of the 78 competence apps, 54 included curricular content that prompted players to answer questions, χ^2 (1) = 10.78, $p < 0.001$.

The majority of these 78 curricular apps (n = 48, 89%) gave auditory or visual responses to a correct answer, χ^2 (1) = 31.12 $p < 0.001$. This meant that a small selection of apps did not give any sort of feedback to the player for a correct answer. In contrast, only 69% (n = 37) of these apps responded to incorrect answers with a visual or auditory response; in other words, 31% (n = 17) apps did not acknowledge the player when an incorrect answer was entered, χ^2 (1) = 6.68, $p < 0.01$. Even more rare were apps offering multiple levels of incorrect answer responses to scaffold the experience (n = 10, 20%, χ^2 (1) = 16.82, $p < 0.001$), such as providing auditory or visual hints to the correct answer choice. Vignette 10 describes the app *Movable Alphabet*, designed to teach spelling. The app did not use any sort of answer feedback system, and thus the player had no way to assess whether a word was spelled correctly.

Another way to scaffold the learning experience with a digital app is through content progress or leveling. Digital learning experiences have the potential to adjust curricular content dynamically based on every user input. For example, the content could level up to a more sophisticated question if the player correctly answers a question or scale down for an incorrect answer. Another way to adjust content could be through player profiles or a parent control panel. Results showed that only a small portion of the reviewed apps leveraged these techniques.

Of the 54 curricular apps, 35 (65%) offered one or more of these content-leveling techniques, χ^2 (1) = 4.16, $p < 0.05$. Of these, 13 combined multiple content progression techniques to adjust curricular content to fit the individual player. The remaining apps employed only one content progress technique to adjust content by player progress within the play session (n = 7), player difficulty selection (n = 9), parent content selection (n = 4), or progress saved to the player's profile (n = 1). Figure 12 shows a screenshot from the app *Montessori Math: 1st Operations* illustrating an example of a parent control panel for selecting curricular content.

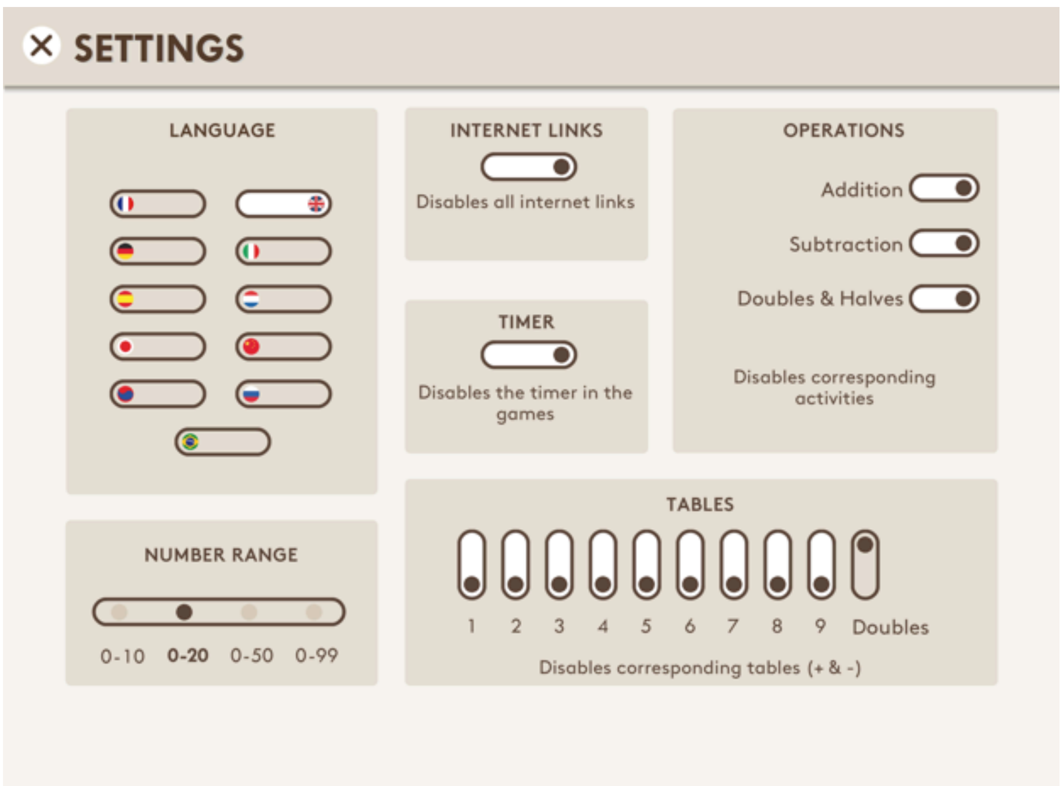


Figure 12. *Montessori 1st Operations*: Adjusts content via the parent menu.

Vignette 10. Movable Alphabet

Target Age: 3+
Price: $3.99
Design Scores:

Interaction	2
Visual	2
Audio	2
Instruction	0

Movable Alphabet is modeled after a common Montessori teaching manipulative that shares the same name. The app comes with a set of images and a tray of letter tiles. Players simply tap on the image to hear its name, such as "CAT," and then drag matching letters next to the image. This activity emulates what might be done in a Montessori classroom.

One major flaw of this app is that it lacks any feedback loop or assessment structure. Players can drag any letters to each matching image, no matter whether the letters would spell the matching word. For example, next to an image of a car, players can drag letters T, P, Y, and X. The app would announce the letter sound of each letter as they are dragged but does not provide any feedback as to whether these letters are part of the word. Furthermore, no matter how the players spell each spread of four words, players can move forward to the next set of images. As such, players are incorrectly reinforced and mistakes are never acknowledged. While this makes a great digital manipulative, it stops short in offering actual teaching or instruction. To learn with this app, the play experience would require adult or parent supervision.

The basic app includes a dataset of CVC words and associated images. To advance to higher levels, which include advance from CVC to 4- and 5-letter words, players have to purchase additional content packs.

4.3.2 Mobile Apps for Fostering Confidence

PTD defines confidence as the willingness to take initiative to master new skills or make choices about what one wants to do to express oneself (Bers, 2012). Results showed that approximately a third of the content offered features to foster confidence and promote self-expression (n = 29, 29%, χ^2 (1) = 16.62, $p < 0.001$). Badges were one common way for games to foster confidence through a permanent reward chart (n = 7). There were many different implementations of the badge system. Some were as simple as showing a set of stars or icons next to successfully completed game and curricular levels. Others were more elaborate, placing badges into a separate interactive game screen. For example, in *Splash Math*, players completed a series of mathematics questions to earn new animals for their jungle (See Figure 13). Instead of static badges, these animals moved about in the jungle and interacted with the player. Players were invited to collect all of these animals to fill up their jungle.

In terms of content affording players opportunities to express themselves creatively, 20 apps included features resembling a blank canvas and art tools or other media creation activities. Many of these, however, did not include art instruction and thus fell short of being curricular. Of these 20 apps, more than half (n = 11) included a portfolio system within the apps so players could save their creations to review them at a later time. Due to the Children's Online Privacy Protection Act (COPPA) regulations, only one of these apps gave children the ability to send and share their creations through the Internet.

4.3.3 Mobile Apps for Encouraging Caring

According to PTD, caring is defined by collaborative activities where multiple children work toward a single task, such as in a cooperative game. Through collaborative play, children have the opportunity to form caring relationships. Despite the affordance of the multi-touch screen and game genres that could appeal to children playing together, this study saw very few apps that fell into this category (n = 9). Six of these activities were synchronous play, either via the network or, more commonly, by splitting the tablet screen into multiple play areas for children to play together in a game. However, this subsample showed that not all multi-player games for young children offered cooperative play. About half of these apps were competitive in nature (n = 4) while others offered a more collaborate environment (n = 5). Even then, most of the social play experiences in these apps were associative (n = 5), with few engaging children in parallel (n = 2) or cooperative (n = 2) play. Vignette 11 describes the app *Match Blitz* as an example of a competitive multiplayer learning game and Vignette 12 describes the app *Drawing Together* as an example of a cooperative game.

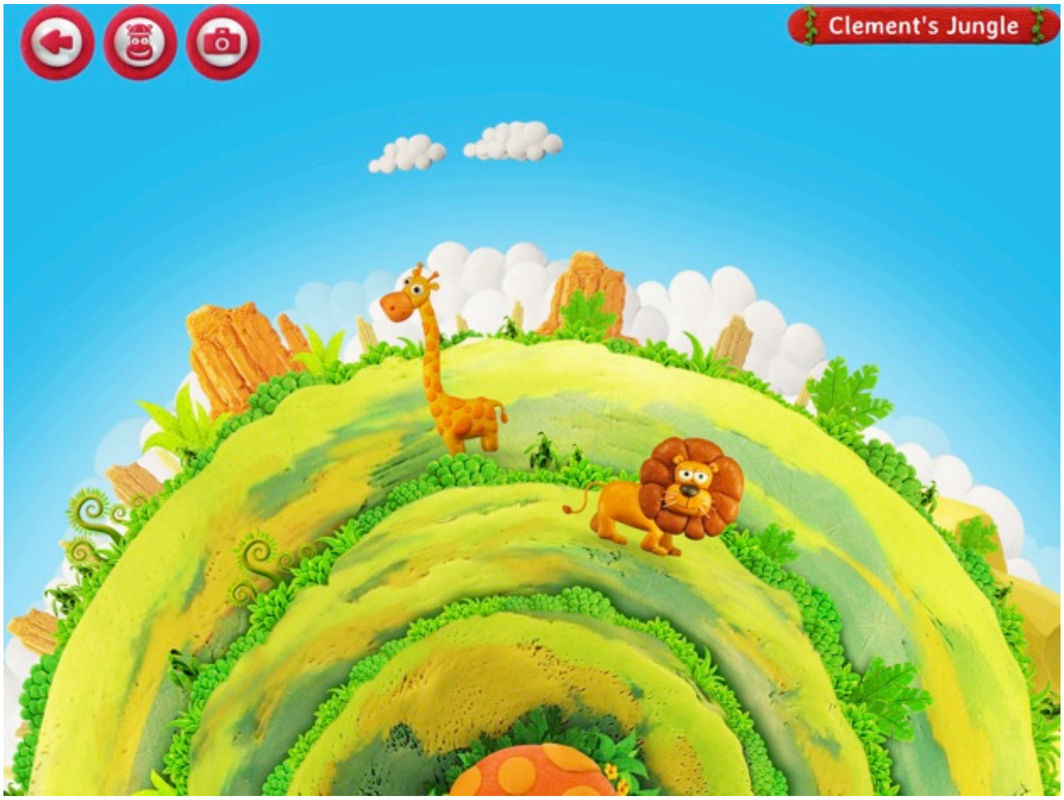


Figure 13. *Splash Math*: Complete game tasks to earn animals for your jungle.

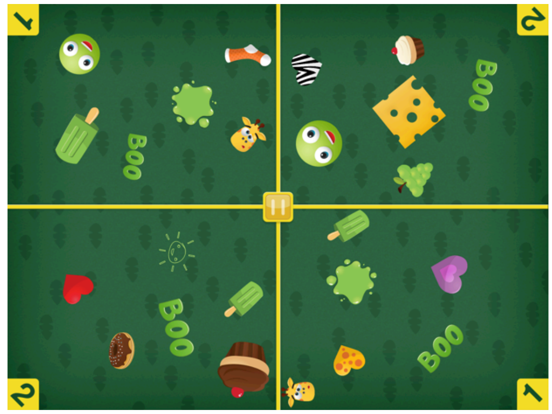
Vignette 11. Match Blitz

Target Age: 4+

Price: Free

Design Scores:

Interaction	3
Visual	4
Audio	0
Instruction	0



Match Blitz is a simple matching game. Players are presented with a set of objects randomly arranged on screen. Among these objects, there are two objects that are identical, though they might be in a different orientation. Players are asked to quickly tap the object that has a duplicate. The game challenges players' visual discrimination skill.

This game can be played in a single player "practice" mode, or as a competitive multiplayer game for up to four players simultaneously. In multiplayer mode, the screen is split into either halves or quadrants. The duplicate object is hidden among the halves or quadrants, so players have to look across other players' areas. For example, in a four-player game, each player's quadrant includes a different mix of images, except the banana shared across all four. Whichever player taps on the banana first wins that round.

The game adjusts to the players' skills automatically. It detects the speed of the players' input and adjusts the difficulty automatically. Based on this information, the game might present the players with more or less distractor objects, the orientation of the matching object, or in the case of a multiplayer game, distractor matches such as an item shared by only two of the four players.

Vignette 12. Drawing Together
Target Age: 4+
Price: $1.99
Design Scores:

Interaction	3
Visual	4
Audio	0
Instruction	0

Many multiplayer game apps are competitive in nature. *Drawing Together* is one of the few that allows players across multiple devices to collaborate simultaneously. Although advertised for ages 0 to 100, this app, given its user interface and the few text labels, seems most appropriate for children aged four and higher.

This app offers two play modes: "Draw by Myself" and "Draw with Friends". In the one-person mode, players can select a canvas or coloring page to draw just like many other children's art and drawing apps. In addition, the app also supplies a set of paper-based game starter backgrounds such as *Tic-Tac-Toe* and *Hangman*. These games, when played by two players, do not require additional computing features.

In the multi-player mode, players can connect to other iPad devices using a six-digit code. This ensures that players are known peers who can share the six-digit code in other manners outside of the app.

Once connected, the two players share the same canvas, despite playing on two separate devices. Just like an art and drawing app, the two players have their own palette of colors and tools to draw onto the canvas. The iPads synchronize continuously so that the two players are always seeing the shared canvas with the most up to date information. In addition, a microphone feature allows the two players to talk to each other as if they are connected by a telephone.

Although this app offers a play experience not much different from two children drawing on a shared piece of paper side-by-side, this app has the potential to connect peers and families who are geographically apart through collaborative and cooperative play.

4.3.4 Mobile Apps for Promoting Connection

According to PTD, connection is promoted by using technology to facilitate social interaction, foster closer relationships with family and peers, and expand one's social network. For many children, the iPad might be the first device they hold that could access the Internet and connect with others via a Wi-Fi network. Yet, only very few apps took advantage of this affordance to support children's social development (n = 7). These apps shared many attributes. Almost all of the apps in this category (n = 6) allowed players, likely with parents' help, to create a contact list to connect with peers and families via the app. Despite the popular concern about children's online safety, only half of these apps (n =4) required parental monitoring, registration, or ongoing involvement to ensure children's safety.

A common theme in this category was apps to facilitate remote storytelling and reading when installed on two separate iPad devices, such as one for a child and another for a parent at a distant location. When connected via the Internet, a parent could choose a book and read to the child using video and voice conferencing capability. Vignette 13 describes one such app, *Kindoma Storytime*, which connects parents and children via networked-supported story time.

4.3.5 Mobile Apps for Fostering Character

In the framework of PTD, character is built by engaging with digital activities offering opportunities to exercise moral reasoning and make choices. Young children often grapple with right or wrong choices by observing the models around them. Seven apps falling into this category represented four types of moral or character lessons: responsibility (n = 1), cultural diversity (n = 2), empathy (n = 1), and self-regulation or behavior control (n = 3). These apps primarily used behavioral modeling (n = 6) as opposed to offering a sandbox for experimenting with different choices and consequences (n = 1). Vignette 14 describes one such app, *Breathe, Think, Do with Sesame*, which integrates behavior modeling in game play.

4.3.6 Mobile Apps for Encouraging Contribution

According to PTD, contribution is fostered by activities in which young children are guided and prompted to contribute to others such as sharing, helping, and contributing to a community project. This study only found three anecdotal examples of such apps. Due to COPPA and other privacy and safety concerns, young children's access to online communities and network-supported collaborative activities was limited. The three apps in this category were primarily creativity oriented and allowed players to submit their creation to their friends (i.e. contact list) (n = 3) or to a closed online community (n = 2). Vignette 15 describes an example of a Contribution app called *Drawp*.

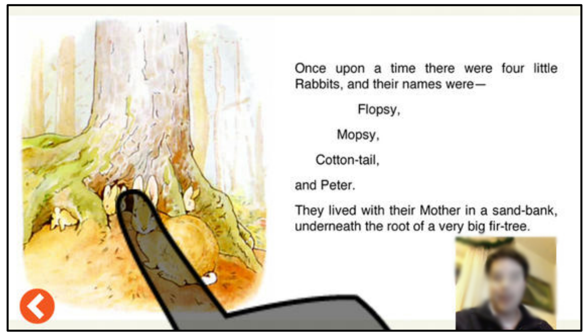
Vignette 13. Kindoma Storytime

Target Age: 2+

Price: Free

Design Scores:

Interaction	2
Visual	4
Audio	0
Instruction	0



Kindoma Storytime is a eBook utility app that allows users to connect with other users of the same app. Similar to other networked apps, this app requires parents to set up a contact list and other security settings prior to use. As this app was intended primarily for parents to read to their children using the iPad, the contact list takes the notion of adding contacts to one's "family."

Once the contact list is set, users can tap to connect to anyone on the contact list. Using the iPad camera, users can see each other on screen similar to a typical video conference software. In addition, a virtual hand appears on both users' screens when one user touches the screen. This allows users to see each other's as they point to images and text on screen. This facilitates common story reading practices where a parent might point to an image on a spread to ask a question, or a child might point to a word to be repeated.

Kindoma Storytime comes free with a small selection of 10 books. It has a large curated library from which users can purchase additional books. Alternatively, users can opt to pay a monthly subscription to access the entire library.

Vignette 14. Breathe, Think, Do with Sesame

Target Age: 4+
Price: Free
Design Scores:

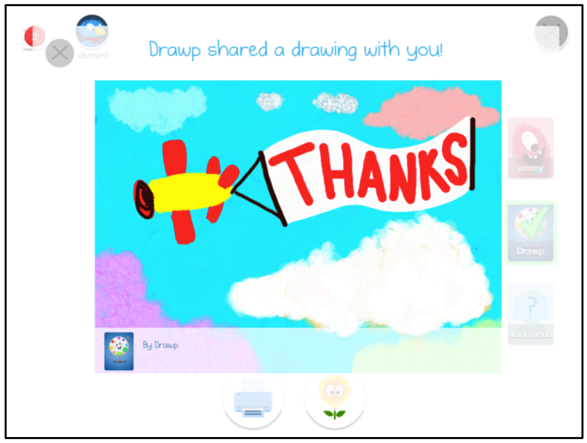
Interaction	4
Visual	4
Audio	3
Instruction	2

Created by Sesame Street, *Breathe, Think, Do with Sesame* teaches children by modeling. Intended for young children, this app presents players with six scenarios in which the game character needs to regulate his or her emotions using the breathe-think-do technique.

An invisible narrator tells a scenario in which characters face a relatable emotional challenge; for example, when getting frustrated because they cannot their his shoes. Players are then taking to a screen where the character appears sad. To make the character feel better, players are asked to tap on the character's belly in a moderate pace. If tapped too fast, the narrator will tell the player to slow down. Tapping the character will make it take three slow breaths. Once that is complete, players are asked to tap on screen bubbles to help the character think of three ways to solve the problem, such as asking an adult for help, learning from someone else, or giving another try. All three plans that the character thinks of will work. Players can select any one of these three and observe an animation sequence that illustrates how it works. Once that is complete, players are congratulated for helping the game character, and the game reviews the breathe-think-do process.

In addition to the invisible narrator, parents can record encouraging phrases to be integrated into the app. Examples of such phrases are "Think of a plan!" or "Keep thinking!" Once recorded, these will replace the specific phrases from the narrator's dialogue to give the app a personalized feel.

Vignette 15. Drawp



Target Age: 3+
Price: Free
Design Scores:

Interaction	3
Visual	2
Audio	1
Instruction	0

Drawp is a networked art and drawing app unlike others on the market. Besides basic features such as a blank canvas, a set of art tools, and a gallery to save completed projects, *Drawp* offers players three ways to share their artwork. The first two ways resemble other networked art and drawing apps. Parents can add multiple profiles onto a single parent account, or add peers to a contact list. Players can then select anyone on either list to send a piece of art work. In addition, players can submit it to the *Drawp* community, which is a pretend social network. Once shared, *Drawp* responds with a drawing as an exchange, which are then saved to the players' inbox. Drawings from *Drawp* are pre-made. The entire exchange process is simulated. However, it offers young players a sense of social networking, community contribution, and exchange. It gives them a social reason to draw and share their creations.

4.4 Developmentally Meaningful Children's Mobile Apps

This study defines *developmentally meaningful* children's mobile apps as apps that are developmentally appropriate, engage children in substantive curriculum, and motivate children to use technology in a way that promotes optimal development. Because this is a newly devised scale, no previous baseline has been established. For the purpose of the present discussion, out of the 16 possible points, an app receiving 8 points or higher could be considered appropriate for young children. Using this as a criterion, results showed that 70% of the apps satisfied a minimum level of design appropriateness, χ^2 (1) = 15.2, $p < 0.001$. Of these apps, 65 engaged children cognitive, socially, emotionally, physically, or academically. Finally, within that subgroup, 58 stimulated behaviors toward positive technological developments. In sum, 58% of the 100 (n = 29, 29%, χ^2 (1) = 0.16, p < ns) were developmentally meaningful.

Chapter Five: Discussion

The objective of this study is to examine the extent to which children's mobiles apps are designed in developmentally appropriate ways to promote optimal development among preschool children. Given the infancy of this space, there is not yet any major longitudinal study on the effect and impact of mobile apps on young children. This study is an initial exploration of this space with respect to what type of digital media experiences are offered to children. In general, the study found a generally positive outlook on this particular landscape in today's children's developmental ecology. The researcher concluded 58% of the 100 apps sampled were developmentally meaningful – that is, they are designed to be developmentally appropriate, engage children in substantive curriculum, and motivate children to use technology in a way that promotes optimal development. This was not a significant majority. However, the findings also showed several surprising results and these are discussed in this chapter.

5.1 Design: What am I supposed to press?

Firstly, mobile apps should be designed to facilitate and support interaction. Young children require unique design practices that accommodate their developmental stage and cognitive abilities. Findings related to audio and instructional designs were most surprisingly negative. The results highlighted a great variability in the developmental appropriateness of children's apps on the market. In particular, the use of developmentally appropriate dialogue and prompts to guide young players was consistently poor across all categories of content. In some cases, as seen in Figure 10, *The Human Body* app, the lack of instructions and visual cues sometimes made it difficult to interpret the goal of the game or the app. Furthermore, the lack of dialogue led to missed opportunities for learning and teaching, as demonstrated in Vignette 5, *Toca Cars*.

Some app developers, like *Toca Boca*, have argued that instructions, prompts, and directions hinder the creative and exploratory nature of children's play. They contend that games with rules inherently dictate a right or wrong way to play and place an emphasis on winning and losing. These attributes of games, they argue, are detrimental to the developing imagination of the young child (Toca Boca, 2013). Instead, they prefer the term *digital toys* to denote digital play experiences that do not have an explicit goal or rules. Instead, these digital toys are designed to allow children to explore the game world as they wish, with no consequences or stated objectives. In some way, these ideas and approaches are a direct reaction to the many drill-and-practice apps that have saturated the market.

This distinction between guided and unguided play experiences is not new and is particularly relevant to the context of preschool children, learning, and development. Researchers have shown that play is instrumental in learning and development in the early years (Hirsh-Pasek, Golinkoff, Berk & Singer, 2008). As with any set of experiences, some are more fruitful than others are. The *playful learning* framework (Fisher, Hirsh-Pasek, Golinkoff, Singer, & Berk, 2010; Hirsh-Pasek et al., 2008; Singer, Hirsh-Pasek & Golinkoff, 2006), divided play into free and guided play. While free play is beneficial to children, it lacks a particular pedagogy and objectives and therefore it is difficult to anticipate the outcome and efficacy of such experiences. Instead, guided play offers a middle ground between didactic instruction and free play, situating intentionally crafted curriculum in a playful setting.

Guided play has two aspects. First, adults enrich the environment with playful yet purposefully selected objects to scaffold and prepare game play infused with curricular content. This is akin to manipulatives in the Montessori approach and the principle of viewing the environment as the *third teacher* in the Reggio Emilia approach. In this approach, the teachers' role is to guide and observe children's activities and enhance their exploration and learning by commenting and reflecting on their discoveries and questions, by asking open-ended questions about their activities, and modeling new ways of interacting and exploring with materials in a manner of which the children might not have conceived. Research in preschool has shown convincing evidence in support of guided play (Fisher et al., 2010).

Keeping the playful learning framework in mind, the results of the present study showed that the current offering of children's iOS mobile apps tended to fall into either the camp of didactic drill-and-practice or free play experiences that lack a purpose. One could argue that the market is direly missing content and experiences that fall closer to the middle of the *play versus learning* spectrum, and app creators and developers must seek more progressive ways of teaching through play.

5.2 Content: Is there anything else to do?

Amidst the wide spectrum of developmental and learning needs, the majority of sampled apps clustered around exercises and practice for early literacy and early mathematics such as counting and number recognition. While some apps attempted to break out of the school subjects in favor of more generalized cognitive skills, they still lacked variety beyond basic matching skills. In some way, this reflects the market and what parents seek. Parents of young children are increasingly demanding academic content rather than play (Vail, 2003). Zigler and Bishop (2006) argued that this view of the cognitive child as a sponge that needs to absorb academic subjects (and specifically the 3 R's) as much and as early as possible can be detrimental to the child's overall development. The emphasis on basic literacy and numeracy might be misplaced. To succeed in school, Zigler and Bishop wrote, "a child must receive appropriate education, of course, but he or she must also be physically and mentally healthy, have reasonable social skills, and have curiosity, confidence, and motivation to succeed" (p. 13).

Among the 100 apps reviewed in this study, there were only six examples of app content that addressed life skills and four that addressed social-emotional learning. Looking at the types of behaviors that these apps engaged, there were only nine examples of social games, of which about half were competitive in nature. Even less common were apps that helped children connect with peers and family, develop a sense of good character, or engage in pro-social behaviors such as sharing and helping.

In reflecting on NAEYC's statement about the potential of digital technology, "When used appropriately…technology and interactive media have the potential to enhance, without replacing, creative play, exploration, physical activity, outdoor experiences, conversation, and social interactions" (2012a, p. 2), the present study found that currently available mobile apps do not widely offer these experiences, nor do they seem to sufficiently and consistently address the range of activities and behaviors as proposed by Bers' PTD framework.

5.3 Dynamics: Where's the Parent?

The study began with an argument that content and context matter in children's use of screen-based digital technology. Parents and teachers can foster a positive technology and screen-rich learning and developmental context that can curb the worries of the numerous speculated negative consequences of screen-time. Specifically, proponents of digital media have argued parents should seize the opportunities to leverage screen time for shared experiences. The have proposed joint media engagement as a rebuttal against the screen-time cynics who continued to picture the solitary child sitting into front of a screen sedentarily for hours on end.

This study found few purposefully designed joint media engagement opportunities in the apps. It is true, parents could always join a child's tablet play session. However, the majority of these apps did not lend themselves to co-play and co-viewing. Even when parents could be involved, such as the case in *PBS Parents Play & Learn*, their role would largely be secondary or ancillary. Instead, many apps offer parents a glimpse into their child's activities through brief report cards accessible either in the app or via email sign up. While the current study is limited in exploring the actual iPad use patterns and behaviors of parents and children, findings largely, pointed to app creators' lack of attention to design experiences that augment or invite joint media attention.

The three example apps in the study that explicitly elicited parent involvement were well thought-out and well executed. They represented joint media engagement in two different ways. *Kindoma* (Vignette 13) and *USTyme* both bring distanced family members closer with the help of video conferencing technology. These two apps epitomized the power of the iPad to engage parents and child in a joint activity even when they cannot be physically together. By comparison, *Write to Read* offered an unusual app built on unique early literacy pedagogy in which adults are guided with video instructions to contribute to the child's writing activities by writing alongside and helping the child recognize the correct spelling of words and labels to accompany a photo-journal.

Amidst a sea of cookie-cutter apps and games, these three apps seemed to offer a fresh experience. Yet, they continually rank behind many other apps in terms of sales and popularity. We need further investigation on the role of parents and the home context around which young children engage with tablets and digital content.

5.4 Limitations

This study intended to present a systematic yet preliminary exploration of the children's mobile app space. As such, it has several limitations.

First, the scope of this study limits the breadth of apps reviewed to only those available for the Apple's iPad. As noted in Chapter 1, this does not provide a comprehensive review of content across all child-friendly tablet platforms. However, Apple's iPad is the most popular tablet on the market (IDC, 2013) and has the largest library of content for preschool children. Therefore, it was a sound choice for sampling reasons. Nonetheless, without further investigation, it is difficult to estimate the generalizability of this study to other platforms.

Second, unlike traditional media with linear presentations, digital apps are interactive and meant to offer the player only glimpses into its design and content. This study uses a content analysis method to review and evaluate a sample of currently available apps on the market. The researcher analyzed the content of these apps as a consumer of the product and as they are designed to be used. Since the researcher does not have access to the source codes of these applications, he might not have captured hidden content and features. Yet, given the comprehensiveness and systematicity of the review process, the findings in the present study should reflect the typical consumer scenario and thus offer valid and relevant contributions to the discussion.

Third, the present study analyzed the content of a sample of children's apps as artifacts. It focused primarily on design features and their hypothesized value for promoting positive development among young children. The present study did not directly observe children's experiences with these apps. Therefore, the present study is limited and constrained from offering any conclusions related to the efficacy of these design techniques, content choice, or pedagogical approaches. The impact of design and content choices can only be evaluated with direct observation of children's use and with experimental techniques.

5.5 Directions for Future Research

Based on the findings and the limitations of this study, the researcher has identified the need for future investigations and research to understand further the efficacy of mobile tablet technologies and software applications to promote optimal development in preschool children. This study generates several possibilities for future research.

(1) *Observation study:* The findings of this study make several postulations about how children might interact with screen-based tablet technology and mobile applications. Nevertheless, this study evaluated only the design and content of a sample of children's mobile apps and therefore conclusions about actual use and impact are limited. Future research can leverage the findings from this study as hypotheses and examine whether they accurately predict the efficacy of these apps.

(2) *Replication study*: As a rapidly growing space, the mobile apps marketplace changes and evolves on a daily basis. Much of the findings from this study refer to what is not accomplished or achieved through artifacts currently available. Innovations and new design strategies might render obsolete some of the comments and conclusions from this study. A replication study in a future time could ascertain whether the findings in this study represent trends or fads, or whether the market and design approaches evolve over time. Similar, A replication study using different sampling criteria, such as selecting samples based on popularity or sales, could also identify potential differences in the quality and affordances of apps that are deemed exemplary by experts versus those that are popular due to marketing and advertising.

(3) *Expanding scope*: The scope of the current study is limited to content available on the Apple iPad, which represents a large but nevertheless partial segment of the market. Future studies may use a similar methodology to examine the content available on other platforms and technologies. While the iPad continues to be the most popular and celebrated choice, it may not represent the best choice for children.

(4) *Secondary content analysis*: This study focused primarily in design techniques and content choices as a survey of the current

landscape of children's mobile apps. Although briefly mentioned in this study, the role of context was not fully explored. Future studies that closely examine the role that culture and gender play in the popularity, quality, and appropriateness of these apps for children's learning and development. Similarly, as discovered in this study, many apps utilized branded characters such as television characters. Secondary content analysis that focuses on the role of brands and commercialization could also help identify potential benefits or draw backs of merging advertising, commercialization, and educational content.

(5) *Comparative study:* This study took a broad stroke survey of the children's mobile apps space. The apps reviewed in this study were selected from across all genre and content types. The study highlighted some differences across genres, but further analyses are needed to fully examine the affordances and constraints of each type of content and how they might be more or less suited for certain types of content and educational goals.

5.6 Conclusions

Surprisingly, results showed just more than half (58%) of the apps were developmentally meaningful. The findings and evaluation tools of this study should not be taken as dictates for design strategies, player dynamics, and content coverage. Rather, one goal of this study is to underscore the developmental needs of preschool children aged three to five and discuss design strategies that accommodate these needs. Nonetheless, the results did not seem to reveal a learning and developmental context that reflects NAEYC's (2012a) position that, "When used appropriately…technology and interactive media have the potential to enhance, without replacing, creative play, exploration, physical activity, outdoor experiences, conversation, and social interactions" (p.2). On the contrary, the present study suggested that the current children's mobile apps space seemed to have limited content offering. Many apps were either developmentally not appropriate for young children or they failed to elicit the types of behaviors that researchers have found to promote optimal development.

These conclusions may lead a grim outlook on the mobile apps market for preschool children. However, this can also been perceived as an opportunity for future development. This study is intended to offer a framework for thinking about tablet and mobile app technology and their potential role in children's development, rather than a critique of current content. Although great developmentally meaningful mobile apps for children were less commonly found in this sample than hoped, the several that passed the muster were exceptional exemplars of where this space can go. As a new ecology for learning and development, these few exemplars of developmentally meaningful mobile apps for children represent true innovations. They point the direction where this technology can go, and how it can create a constructive, meaningful, and valuable niche for PTD. As Alan Kay (1972) wrote of his DynaBook, "This new medium will not save the world" (p. 1). But creating a better future requires creativity in the present. I hope that the present study will inspire future content developers and influencers to cultivate the mobile apps space to the benefit of children.

Appendices

List of Appendices

The Children's Apps Categorization Form

Name of App: ____________________ **Target Age:** ______________________

Content Type:

☐ Game App – ☐ Academic ☐ Non-academic

☐ eBook – ☐ Non-Interactive ☐ Read to Me only ☐ Read & Play

☐ Utility – ☐ Utility ☐ Productivity

If Game, check all that apply:

☐ Instructive – Drill & practice with correct/incorrect answers or moves

☐ Manipulable – Allows players to use digital artifacts to explore and learn

☐ Puzzle – Series of cognitively challenging activities, little to no narrative

☐ Role Play – Players take on a role to navigate through a narrative

☐ Simulation – Players empowered to experiment with the environment

☐ Casual – Mindless, repetitive; does not challenge players cognitively

☐ Other – Describe:______________________________________

What are the general skills exercised or the curriculum?

☐ Mathematics ☐ Literacy ☐ Social Studies ☐ Science

☐ Physical Dev. ☐ Art/Music ☐ Social/Emotional ☐ Life Skills

☐ General Cognition ☐ Just for Fun ☐Other: ______________________

The Developmentally Appropriate App Design Form

Name of App: ________________________ **Target Age:** ______________________

I. Interaction Design

1. Circle all gestures used (2 = primarily top; 1 = mix; 0 = primarily bottom):

Tap	**Trace**	**Swipe**	**Drag**	**Slide**
Pinch	**Tilt/Shake**	**Flick**	**Multi-touch**	**Double Tap**

2. Use of visual cues (sparkles, animations) to highlight UI? **YES** **NO**

3. Does UI avoid use of text labels and conventional symbols? **YES** **NO**

II. Visual Design

1. Visual mechanics separate hot spots from background? **YES** **NO**

2. Are visual mechanics consistent through the app? **YES** **NO**

3. Scene draw focus to game goal w/ little distractions? **YES** **NO**

4. NIS, scenes, & text confirms to left-right, top-down? **YES** **NO**

III. Audio Design

1. Instructions spoken by: **Character**(2) **Narrator**(1) **None**(0)

2. Are instructions interruptible after first entry? **YES** **NO**

3. Are audio instructions accompanied by visuals cues? **YES** **NO**

IV. Instructional Design

1. Form of *How-to-play* tutorial:

Interactive(3) **Visual only**(2) **Audio only**(1) **Text only**(1) **None**(0)

2. Inactivity prompt to guide user interaction? **YES** **NO**

V. Parent Feature

Describe the parent feature, if any:

The Positive Technological Development for Young Children Form

Name of App: ____________________ **Target Age:** ______________________

I. **Competence –** offers content to exercise or build new skills.

1. Does this app include content related to *Competence*? **YES** **NO**
2. Correct answer or game task rewarded with a/v response? **YES** **NO**
3. Incorrect answer/game task returns clear a/v response? **YES** **NO**
4. Multiple incorrect on same task returns different hints? **YES** **NO**
5. Does it offer any of the following personalization features?
   i. Adjust content based on progress? **YES** **NO**
   ii. Adjust content based on login? **YES** **NO**
   iii. Adjust content based on user-selected level? **YES** **NO**
   iv. Parents select and adjust content for child? **YES** **NO**

II. **Confidence –** empowers the child to express or seek help when needed.

1. Does this app include content related to *Confidence*? **YES** **NO**
2. Does this app use a badge or star system to track success? **YES** **NO**
3. Does this app offer tools to create and express the self? **YES** **NO**
4. Does this app allow users to keep creation in a portfolio? **YES** **NO**
5. Does this app offer any on-demand help or support? **YES** **NO**

III. **Caring -** collaborative play in which the child interacts with peers.

1. Does this app include content related to *Caring*? **YES** **NO**
2. Timing: **Asynchronous** **Synchronous**
3. Scope: **Pair** **Group**
4. Nature: **Collaborative** **Competitive**
5. Social Dimension: **Parallel** **Associative** **Cooperative**

IV. Character - moral reasoning through modeling or experimentation.

1. Does this app include content related to *Character*? **YES** **NO**
2. Describe the type of ethical or moral decision the player has to make:
3. Is there a positive model to demonstrate good behavior? **YES** **NO**
4. Can the player experiment with different choices? **YES** **NO**

V. Contribution - exercise pro-social behaviors e.g. helping and sharing.

1. Does this app include content related to *Contribution*? **YES** **NO**
2. Can the player share creation with friends/family? **YES** **NO**
3. Can the player share creation with an online community? **YES** **NO**
4. Does the app encourage the player to help friends/family? **YES** **NO**
5. Does the app encourage contribution to community? **YES** **NO**

Rating Data of 100 Children's Mobile Apps

	App Name	Competence	Confidence	Caring	Connection	Character	Contribution	Interaction	Visual	Audio	Instruction
1	Pigeon Presents, Mo on the Go!							4	4	3	3
2	Match Blitz	X		X				3	4	0	0
3	Grandma Loves Bugs	X						4	4	4	3
4	Fairytale Maze 123	X						4	4	0	0
5	ChatterPix Kids		X					4	4	0	2
6	All Fixed Up	X						2	3	1	0
7	The Tale of a Snowflake	X						3	3	1	0
8	Todo Telling Time	X						4	4	2	1
9	Teachley: Addimal Adventure	X						4	4	3	4
10	The Pirate Princess	X						3	3	2	1
11	Sofia the First Story Theater	X	X					4	4	2	0
12	Quick Tap Spanish	X		X				3	4	0	0
13	MyScript Calculator	X						4	4	0	1
14	Moose Math	X						3	4	3	2
15	Montessori Math: 1st Operations	X						3	4	3	3
16	US Geography With Flat Stanley	X	X					2	4	0	2
17	DragonBox Algebra 5+	X	X					3	4	0	2
18	Cosmic Reactor	X		X				4	4	1	2
19	NameGames	X			X			2	4	3	1
20	Shiny Picnic	X						3	4	1	0
21	Writing Wizard	X	X					3	4	1	3
22	More Trucks							3	3	2	2
23	Mickey Mouse: Paint & Play		X					4	4	4	1
24	Dr. Panda's Supermarket	X						3	3	0	1
25	Dr. Panda's Home	X				X		3	3	0	1
26	Daniel Tiger's Day & Night	X	X					4	4	4	2
27	Grandma's Kitchen	X						3	4	3	2
28	Frozen: Storybook Deluxe	X						3	4	2	2
29	Jetpack Journeys	X						3	4	0	0
30	Rainbow Sentences	X	X					2	4	1	2
31	Loopy Lost His Lettuce	X						2	1	1	2
32	Chug Patrol Ready to Rescue	X						3	4	3	3

	App Name	Competence	Confidence	Caring	Connection	Character	Contribution	Interaction	Visual	Audio	Instruction
33	Bugs and Buttons 2	X						2	4	2	2
34	Alphabeasties	X						4	4	1	2
35	ABC Actions	X						4	4	2	2
36	Playground 3 - ABC Edition	X						4	4	1	0
37	The Jungle Book	X						3	4	1	2
38	Haunted House Activity Book	X						3	4	1	2
39	Grimm's Sleeping Beauty	X						3	4	1	2
40	Four Little Corners	X				X		4	4	1	0
41	Preschool Maze 123	X						4	4	0	0
42	Play Lab	X						3	4	0	1
43	Pitch Painter		X					2	3	0	1
44	Petting Zoo							2	4	1	2
45	Peppa Pig Happy Mrs. Chicken	X						3	4	3	2
46	Sparky's Birthday Surprise	X						3	4	1	0
47	StoryPanda	X	X		X			3	3	0	0
48	Williamspurrrg							1	2	0	2
49	Spatter & Spark	X	X					3	2	3	1
50	Meet the Insects	X						2	4	2	0
51	Joy and Misty	X						0	1	2	2
52	Write to Read - WriteReader	X	X	X				2	3	0	0
53	Magic Stickers		X					3	4	3	3
54	InfiniScroll							3	2	2	1
55	Pan II: Chasing the Keeper	X						4	2	0	3
56	Sago Mini Sound Box		X					3	4	0	1
57	Touch, Look, Listen: 1st Words	X						3	4	2	0
58	StoryToys Jr. Farm 123	X						2	4	2	1
59	Shiny Party	X						3	4	1	1
60	Sago Mini Pet Cafe							4	4	0	0
61	Sago Mini Forest Flyer							4	4	0	0
62	Matching Puzzle Cards: Colors	X						3	4	1	2
63	Just Going to the Dentist	X						3	3	2	3
64	Dexteria Jr.	X						3	4	1	1
65	Wubbzy's Magic School	X						2	4	2	0
66	Wubbzy's Dance Party	X						2	4	2	1
67	Toca Hair Salon Me		X					3	4	0	0
68	Toca Cars		X					3	4	0	0

	App Name	Competence	Confidence	Caring	Connection	Character	Contribution	Interaction	Visual	Audio	Instruction
69	Splash Math Kindergarten	X						2	4	1	1
70	Duckie Deck: Collector	X				X		3	3	0	1
71	Mathtopia+	X	X					2	4	0	2
72	Curious about Shapes & Colors	X	X					4	4	4	3
73	Endless Alphabet	X						4	4	2	2
74	Sago Mini Bug Builder		X					4	4	0	1
75	StoryBots Tap & Sing		X					4	4	0	4
76	The Human Body	X						3	3	0	0
77	ABC Farm	X						3	4	3	2
78	Brave: Storybook Deluxe	X						3	3	1	1
79	Easy Studio	X	X					3	4	0	3
80	Roadtrip Bingo			X				2	4	0	0
81	Montessori Math: 1st Operations	X						2	4	0	1
82	Motion Math: Match	X	X					2	4	0	2
83	Kindoma Storytime	X			X			2	4	0	0
84	Luca Lashes Visits the Doctor	X						2	1	1	0
85	PLAY-DOH Create ABCs	X	X					1	4	2	2
86	Tiny Tap		X				X	2	4	0	2
87	Touch 'n Sing	X						2	3	2	1
88	PBS Parents Play & Learn App	X						2	3	2	1
89	Movable Alphabet	X						2	2	2	0
90	Drawing Together		X	X	X			3	4	0	0
91	USTyme	X		X	X			2	4	0	0
92	Draw Together		X	X				2	2	0	0
93	Drawp		X	X	X		X	3	2	1	0
94	Peek-a-Zoo	X						2	4	2	0
95	Toca House	X						3	4	0	0
96	Toca Pet Doctor					X		3	4	0	0
97	Wee-You Things	X	X			X		1	3	2	0
98	Breathe, Think, Do w/Sesame St.	X				X		4	4	3	2
99	Maily		X		X		X	3	4	0	0
100	Calm Counter	X				X		4	4	2	2

References

148apps.biz. (2013, December). *App Store Metrics*. Retrieved December 23, 2013 from http://148apps.biz/app-store-metrics.

9to5mac.com. (2013, May 15). Apple's App Store reaches 50 billion downloads. Retrieved December 23, 2013 from http://9to5mac.com/2013/05/15/apples-app-store-reaches-50-billion-downloads.

American Academy of Pediatrics. (1999). Media Education. *Pediatrics, 104*, 341-343.

American Academy of Pediatrics. (2011). Media use by children younger than 2 years*. Pediatrics, 128*(5), 1040-1045.

American Academy of Pediatrics. (2011b). Children, adolescents, obesity, and the media. *Pediatrics, 128*(1), 201-208.

American Academy of Pediatrics. (2013). Children, adolescents, and the media. *Pediatrics, 132*(5), 958-961.

Anderson, D. & Lorch, E. (1983). Looking at television: Action or reaction? In *Children's Understanding of Television: Research on Attention and Comprehension* (Eds. J. Bryant & D. Anderson). Pp. 1-31. New York: Academic Press.

Apple Computers. (2014). *App Store Review Guidelines.* Retrieved on February 15, 2014 at developer.apple.com/appstore/guidelines.html

Arrowood, D. & Overall, T. (2004). Using technology to motivate children to write: Changing attitudes in children and preservice teachers. In R. Ferdig et al. (Eds.), *Proceedings of Society for Information Technology &*

Teacher Education International Conference 2004. (pp. 4985-4987). Chesapeake, VA: AACE.

Barron, B., Martin, C., Takeuchi, L., & Fithian, R. (2009). Parents as learning partners in the development of technological fluency. *International Journal of Learning and Media, 1*(2), 55-77.

Berelson, B. (1952). *Content Analysis in Communication Research*. New York: Free Press.

Berndt, T. J. (1997). *Child Development*. Madison, WI: Brown & Benchmark Publishers.

Bers, M. (2006). The role of new technologies to foster positive youth development. *Applied Developmental Science, 10*(4), 200-219.

Bers, M. (2010). The TangibleK Robotics Program: Applied computation thinking for young children. *Early Childhood Research and Practice, 12*(2).

Bers, M. (2012). *Designing Digital Experiences for Positive Youth Development*. New York: Oxford.

Bers, M. & Chau, C. (2010). The virtual campus of the future: Stimulating and simulating civic actions in a virtual world. *Journal of Computing in Higher Education, 22*(1), 1-23.

Bers, M., Beals, L., Chau, C., Satoh, K., and Khan, N. (2010). Virtual worlds for young people in a program context: Lessons from four case studies. *New Science of Learning: Cognition, Computers, and Collaboration in*

Education. (Eds. M. Khine and I. Saleh). Pp. 357-383. Springer Publishing Company.

Blurton-Jones, N. (1972). Categories of child interaction. In N. Blurton-Jones (Eds.), *Ethological Studies of Child Behavior,* (pp. 97-129). London: Cambridge University Press.

Borse, J. & Sloan, K. (2005). *A case study of DyKnow Vision: Conversations and observations that demonstrate its educational potential.* San Francisco, CA: Rockman et al.

Bredekamp, V.S. & Copple, C. (1997). *Developmentally Appropriate Practice in Early Childhood Programs*. Washington, DC: NAEYC.

Bretherton, I. (1986). Reality and fantasy: Representing the social world in symbolic play. In A. Gottfried (Ed.), *Play interactions: The Contribution of Play Materials and Parental Involvement to Child Development.* (pp. 119-148). Lexington, Massachusetts: Lexington Press.

Buckingham, D. & Scanlon, M. (2003*). Education, Entertainment, and Learning in the Home.* Philadelphia: Open University Press.

Buckleitner, W. (1985). *Children's Interactive Media Rating Instrument.* Retrieved from http://childrenstech.com/about/ratings.

Buckleitner, W. (2012, November 21). Toy tablets for children, or the real thing? *The New York Times, p. B9.*

Charmaz, K. (2006). *Constructing Grounded Theory*. London: Sage.

Cherian, M. (2009). *From PLATO to podcasts: Fifty years of federal involvement in educational technology*. Center on Education Policy: Project on Rethinking the Federal Role in Elementary and Secondary Education.

Children's Technology Review. (2014, January). 2013 in review: Top 107 children's apps. *Children's Technology Review, 22*(1), 5-22.

Chiong, C., & C. Shuler. 2010. *Learning: Is There an App for That? Investigations of Young Children's Usage and Learning with Mobile Devices and Apps*. New York: The Joan Ganz Cooney Center at Sesame Workshop.

Common Sense Media. (2013). *Zero to Eight: Children's Media Use in America 2013.* San Francisco, CA: Victoria Rideout.

Comstock, G. & Paik, H. (1991). *Television and the American Child*. San Diego, CA: Academic Press.

Corbin, J. & Strauss, A. (2008). *Basics of Qualitative Research: Technique to Developing Grounded Theory (3rd Ed.).* Los Angeles, CA: Sage.

Couse, L. J., & Chen, D. W. (2010). A Tablet Computer for Young Children? Exploring Its Viability for Early Childhood Education. *Journal Of Research On Technology In Education,43*(1), 75-98.

Creswell, J. W. (2002). *Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Approaches to Research*. Upper Saddle River, NJ: Merrill/Pearson Education.

Crosser, S. (1996). Emerging morality: How children think about right and wrong. *Early Childhood News, 8*(1), 11-16.

Crawford, C. (1982). *The Art of Computer Game Design.* Berkeley, CA: Osborne/McCraw-Hill.

Duffy, T. & Jonassen, D. (1992). *Constructivism and the Technology of Instruction: A Conversation*. Hillsdale, New Jersey: Lawrence Erlbaum Associates, Inc.

Dundon, M., McLaughlin, T. F., Neyman, J., & Clark, A. (2013). The effects of a model, lead, and test procedure to teach correct requesting using two apps on an ipad with a 5-year-old student with autism spectrum disorder. *Educational Research International, 1*(3), 1-10.

Dyson, A. H. (1997). *Writing superheroes: Contemporary childhood, popular culture, and classroom literacy*. Williston, VT: Teachers College Press.

Eisenberg, N. (1992). *The Caring Child.* Cambridge, MA: Harvard University Press.

Erikson, E. (1950). *Childhood and Society*. W. W. Norton and Company.

Fisch, S. M., Akerman, A., Morgenlander, M., McCann-Brown, S., K., Fisch, S., Schwartz, B. & Tobin, P. (2008). Coviewing preschool television in the US: Eliciting parent-child interaction via onscreen prompts. *Journal of Children and Media, 2*(2), 163-173.

Fisch, S. M., Shulman, J. S., Akerman, A., & Levin, G. (2002). Reading between the pixels: Parent-child interaction while reading online storybooks. *Early Education and Development, 13* 435-451.

Fisher, K., Hirsh-Pasek, K .,Golinkoff, R. M., Singer, D., & Berk, L. E. (2010). Playing around in school: Implications for learning and educational policy. In A. Pellegrini (Ed.), *The Oxford handbook of play.* NY: Oxford University Press, 341-363.

Gardner, H. & Davis, K. *The App Generation*. New Haven, Connecticut: Yale University Press.

Gasch, S. (2005, December). *Alan Kay*. Retrieved March 13, 2014, from http://ei.cs.vt.edu/~history/GASCH.KAY.HTML#4

Gee, J. P. (2003). *What Video Games Have to Teach Us about Learning and Literacy*. New York: Palgrave Macmillan.

Geist, E. A. (2012). A qualitative examination of two year-olds interaction with tablet based interactive technology. *Journal Of Instructional Psychology, 39*(1).

Glaser, B. (1998). *Doing Grounded Theory: Issues and Discussion.* Mill Valley, CA: Sociology Press.

Goodwin, K. (2009). *Impact and affordances of interactive multimedia,* Doctoral dissertation, Macquarie University, Sydney.

Goodwin, K., & Highfield, K. (2012) iTouch and iLearn: an examination of 'educational' Apps. Paper presented at the *Early Education and Technology for Children* conference, March 14-16, 2012, Salt Lake City, Utah.

Goodwin, K., & Highfield, K. (2012). iTouch and iLearn: an examination of 'educational' Apps. Paper presented at the *Early Education and Technology for Children conference,* March 14-16, 2012, Salt Lake City, Utah.

Guernsey, L. (2012). *Screen Time: How Screen Time Affects Children From Birth to Age Five.* New York, New York: Basic Books.

Guernsey, L., Levine, M., Chiong, C., & Severns, M. (2012). *Pioneering Literacy in the Digital Wild West: Empowering Parents and Educators*. New America Foundation.

Guthrie, L. F. & Richardson, S. (1995). Language arts: Computer literacy in the primary grades. *Educational Leadership, 53*(2), 14-17.

Handal, B, El-Khoury, J., Campbell, C., & Cavanagh, M. (2013). A framework for categorising mobile applications in mathematics education. *Education Conference Papers. Paper 70.*

Hart, C., Burts, D., & Charlesworth, R. (1997). *Integrated Curriculum and Developmentally Appropriate Practice: Birth to Age Eight*. Albany, New York: State University of New York Press.

Harter, S. & Pike, R. (1983). *The Pictorial Scale of Perceived Competence and Social Acceptance for Young Children*. Denver, CO: University of Denver.

Haughland, S. W. (1999). What role should technology play in young children's learning? *Young Children, 54*(6), 26-31.

Haugland, S. (1998). The best developmental software for young children. *Early Childhood Education Journal, 25*(4), 247-254.

Hirsh-Pasek, K., Golinkoff, R. M., Berk, L. E., & Singer, D. (2008). *A mandate for playful learning in preschool: Applying the scientific evidence*. Oxford University Press.

Holland, J. & Skinner, B. F. (1961). *The Analysis of Behavior: A Program for Self-Instruction.* New York: McGraw Hill.

Holmberg, M. C. (1980). The development of social exchange patterns from 12 to 42 months. *Child Development, 51*, 448-456.

Holsti, O. (1969). *Content Analysis for the Social Sciences and Humanities*. Don Mills: Addison-Wesley Publishing Company.

Howes, C. (1983). Pattern of friendship. *Child Development, 54,* 1041-1053.

Hsieh, H. F. & Shannon, S. E. (2005). Three approaches to qualitative content analysis. *Qualitative Health Research, 15*(9), 1277-1288.

Hunicke, R., LeBlanc, M., & Zubek, R. (2004). MDA: A formal approach to game design and game research. In *Proceedings of the Challenges in Games AI Workshop*, *Nineteenth National Conference of Artificial Intelligence*.

Huston, A. C., et al. (1992). *Big World, Small Screen: The Role of Television in American Society*. Lincoln, Nebraska: University of Nebraska Press.

IDC. (2013, October 30). Android growth drives another strong quarter for the worldwide tablet market. *Press Release*. Retrieved from http://www.idc.com/.

Ito, M. (2009). *Engineering Play: A Cultural History of Children's Software*. Cambridge, Massachusetts: MIT Press.

Kay, A. (1972, August). *A personal computer for children of all ages*. Retrieved March 14, 2014, from mprove: http://www.mprove.de/diplom/gui/kay72.html

Kinder, M. (1991). *Playing with Power in Movies, Television, and Video Games: From Muppet Babies to Teenage Mutant Ninja Turtles.* Berkeley, CA: University of California Press.

Kleeman, D. (2010, December 8). "A screen is a screen is a screen" is a meme. *Huffington Post*. Retrieved from http://www.huffingtonpost.com.

Knorr, C. (2010, October 20). What's better for kids: Computers, TV, or games?. *Common Sense Media*. Retrieved from http://www.commonsensemedia.org.

Kohlberg, L. 1984). *Essays on Moral Development, Volume II: The Psychology of Moral Development.* San Francisco, CA: Harper & Row.

Koper, R. (2006). Current research in learning design. *Educational Technology & Society, 9*(1), 13-22.

Landis, J. R. and Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics, 33*, 159-174.

Lauricella, A., Gola, A.A.H. & Calvert, S.L. (2011). Meaningful characters for toddlers learning from video. *Media Psychology, 14*, 216-232.

Lenahrt, A. (2003). *The Ever-Shifting Internet Population: A New Look at Internet Access and the Digital Divide*. Washington D.C.: Pew Internet Research.

Lerner, R. M., Lerner, J. V., Almerigi, J., et al. (2005). Positive youth development, participation in community youth development programs, and community contributions of fifth grade adolescents:

Findings from the first wave of the 4-H Study of Positive Youth Development. *Journal of Early Adolescence, 25*(1), 17-71.

Mathews, J. & Seow, P. (2007). Electronic paint: Understanding children's representation through their interactions with digital paint. J*ournal of Art Design, 26*(3), 251-263.

McLuhan, M. (1964). *Understanding Media.* New York: Mentor.

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

McManis, L.D., & J. Parks. 2011. *Evaluating Technology for Early Learners. E-book and Toolkit.* Winston-Salem, NC: Hatch Early Learning.

Miliband, D. (2005). *Choice and voice in personalized learning*. Personalising Education. OECD.

Milman, N. B., Carlson-Bancroft, A., & Boogart, A. V. (2012). Ipads in a prek-4th independent school–year 1–enhancing engagement, collaboration, and differentiation across content areas. In *ISTE conference*. San Diego, CA.

Moore, N., Evertson, C., & Brophy, J. (1974). Solitary play: Some functional reconsiderations. *Developmental Psychology, 10*, 830-834.

Napier, C. (2014). How use of screen media affects the emotional development of infants. *Primary Health Care, 24*(2), 18-25.

National Associations for the Education of Young Children. (2009). *Developmentally Appropriate Practice in Early Childhood Programs*

Serving Children from Birth through Age 8. Position Statement. Pp. 1-32.

National Associations for the Education of Young Children. (2012). *Technology and Interactive Media as Tools in Early Childhood Programs Serving Children from Birth Through Age 8.* Position Statement. Pp. 1-15.

Nielsen (20120). *American Families See Tablets as Playmate, Teacher and Babysitter.* Retrieved: http://www.nielsen.com.

Palfrey, J. & Gasser, U. (2008). *Born Digital: Understanding the First Generation of Digital Natives.* New York: Basic Books.

Papert, S. (1980). *Mindstorms: Children, Computers, and Powerful Ideas.* Basic Books.

Papert, S. (1990). *A critique of technocentrisum in thinking about the school of the future.* E&L Memo NO. 2, Epistemology and Learning Group. Boston: MIT Media Laboratory.

Papert, S. (1993). *The Children's Machine: Rethinking School in the Age of the Computer*. New York: Basic Books.

Parten, M. (1932). Social participation among preschool children. *Journal of Abnormal and Social Psychology, 28*(3), 136-147.

Patton, M. (1990). *Qualitative evaluation and research methods. Second Edition.* Newbury Park, CA: Sage.

Piaget, J. (1932/1965). *The Moral Judgment of the Child.* (M. Gabain, Trans.) New York: Free Press.

Piaget, J. (1952). *The Origin of Intelligence in Children*. New York: International Universities Press.

Prensky, M. (2006). *Don't Bother Me Mom-I'm Learning*. St. Paul, Minn.:Paragon House.

Richard, M. (2008). *Why the iPhone makes 2008 seem like 1968 all over again*. Open2.net by The Open University. Retrieved from http://www.open.edu/.

Richards, J., Stebbins, L., & Moellering, K. (2013). Games for a Digital Age: K-12 Market Map and Investment Analysis. New York: Joan Ganz Cooney Center at Sesame Workshop.

Rubin, K. H. (1982). Non-social play in preschoolers: Necessary evil? *Child Development, 53,* 651-657.

Rubin, K. H., Watson, K. S., & Jambor, T. W. (1978). Free play behavior in preschool and kindergarten children. *Child Development, 48,* 534-536.

Sandvik, M., Smørdal, O., & Østerud, S. (2012). Exploring iPads in practitioners' repertoires for language learning and literacy practices in kindergarten. *Nordic Journal of Digital Literacy, 7*(3), 204-220.

Schmidt, M. E. & Vandewater, E. A. (2008). Media and attention, cognition, and school achievement. *Children and Electronic Media, 18*(1), 63-85.

Schnelle, J. (2008). *The Art of Game Design: A Book of Lenses.* Boca Raton, FL: CRC Press.

Schuler, C. (2012). *iLearn II: An Analysis of the Education Category of the iTunes App Store.* New York: The Joan Ganz Cooney Center at Sesame Workshop.

Seiter, E. (1999). *Television and New Media Audiences*. NY: Oxford University Press.

Selman, R. (1980). *The Growth of Interpersonal Understanding: Developmental and Clinical Analysis.* New York: Academic Press.

Sesame Workshop. (2012). *Best Practices: Designing Touch Tablet Experiences for Preschoolers*. New York: Sesame Workshop.

Singer, J. (1980). The power and limits of television: A cognitive-affective analysis. In *The Entertainment Function of Television* (Ed. P. Tannenbaum). Hillsdale, N. J: Lawrence Erlbaum.

Singer, D. G., Golinkoff, R. M., & Hirsh-Pasek, K. (2006). *Play: How play motivates and enhances children's cognitive and social-emotional growth*. New York, NY: Oxford University Press.

Squire, K., 2008. Open-ended video games: A model for developing learning for the interactive age. *The Ecology of Games: Connecting Youth, Games, and Learning*. Katie Salen (Ed). The John D. and Catherine T. MacArthur Foundation Series on Digital Media and Learning. Cambridge, MA: The MIT Press, 167–198.

Stevens, R. & Penuel, W. R. (2010). *Studying and fostering learning through joint media engagement.* Paper presented at the Principal Investigator

Meeting of the National Science Foundation's Science of Learning Centers, Arlington, VA.

Subrahmanyam, K., Kraut, R., Greenfield, P., & Gross, E. (2000). The impact of home computer use on children's activities and development. *The Future of Children: Children and Computer Technology, 10*(2), 123–144.

Sullivan, H. S. (1953). *The Interpersonal Theory of Psychiatry*. New York: Norton.

Swinton, S.S., Amarel, M., & Morgan, J.A. (1978). *The Plato elementary demonstration educational outcome evaluation. Final report: Summary and conclusions*. Urbana, IL: University of Illinois.

Takeuchi, L. & Stevens, R. (2011). *The New Coviewing: Designing for Learning Through Joint Media Engagement.* New York: Joan Ganz Cooney Center at Sesame Workshop.

Talley, S., Lance, D. F., & Lee, T. R. (1997). Children, storybooks and computers. *Reading Horizons, 38*(3), 116-128.

Tapscott, D. (1998). *Growing Up Digital: The Rise of the Net Generation*. New York: McGraw-Hill.

Tashakkori, A. & Teddlie, C. *Handbook of Mixed Methods in Social and Behavioral Research*. *Second Edition.* Thousand Oaks, CA: Sage Publications.

Toca Boca. (2013). *A digital toy or a game – what's the difference?* Toca Boca Support FAQ. Retrieved from https://tocaboca.desk.com/

US Dept. of Education. (2010). *National Educational Technology Plan.*

Van Meer, E. (2003). PLATO: From computer-based education to corporate social responsibility. *Iterations: An Interdisciplinary Journal of Software History, 2,* 1-22.

Vail, K. (2003, November). Ready to learn. What the Head Start debate about early academics means for your schools. *American School Board Journal, 190*.

Veldhuis, L., van Grieken, A., Renders, C. M., HiraSing, R. A., & Raat, H. (2014). Parenting Style, the Home Environment, and Screen Time of 5-Year-Old Children; The 'Be Active, Eat Right' Study. *Plos ONE, 9*(2), 1-9.

Vernadakis, N., Avgerinos, A., Tsitskari, E., & Zachopoulou, E. (2005). The use of computer-assisted instruction in preschool children: Making teaching meaningful. *Early Childhood Education Journal, 33*(2), 99-104.

Vygotsky, L. (1978) *Mind in Society*. Harvard University Press.

Watlington, D. (2011). Using iPod Touch and iPad Educational Apps in the Classroom. In M. Koehler & P. Mishra (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference 2011*(pp. 3112-3114). Chesapeake, VA: AACE.

Zigler, E. F., & Bishop-Josef, S. J. (2006). The cognitive child versus the whole child: Lessons from 40 years of Head Start. *Play= learning: How play motivates and enhances children's cognitive and social-emotional growth*, 15-35.