OUT OF TOUCH : An Investigation of the Disconnect Between ‘Educational’ App Design and Research

Samuel Joe

A thesis/dissertation/exegesis submitted to Auckland University of Technology in partial fulfilment of the requirements for the degree of Master’s of Creative Technologies

2017

Creative Technologies

Abstract

This paper considers the design of tablet applications that promote reading development features in relation to current educational theory and research on the learning and development of children aged 3 - 7. As children read, interact and view content on mobile devices it has become evident that digital technologies are shaping early literacy practices. The features and functions of 'educational' reading applications are reflective of how their designers and developers believe children learn. Many existing applications seem to be out of touch with learning theory and this paper responds with a design approach that is adapted to produce conceptual prototypes which translate aspects of learning theory into app features.

Table of Contents

List of figures:

Attestation of Authorship

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

Signed:

Acknowledgements:

I would like to thank my lead supervisor, Dr Frances Joseph, for patiently guiding me throughout all of the post graduate process. The continued advice and encouragement she gave enabled me to continue past numerous setbacks and persevere till this project's completion.

My secondary supervisor, Dr Andrew Gibbons, helped me to frame the project and advised me of the directions I could investigate in my research. His knowledge and approach to the material were very valuable and influential in shaping my own understandings of the area.

I would also like to thank my family, friends and my partner Ash for their love and support through researching and writing this paper. This accomplishment would not have been possible without them. Thank you.

Chapter 1 - Introduction

The use of iPads, tablets, smartphones and other mobile touch screen technologies has become ubiquitous in modern daily lives. Many of today's children are exposed to these devices at a young age and app developers are capitalizing on this emerging market; creating a large

variety of both leisure and learning applications. As children read, interact and view content on these devices it has become evident that digital technologies are shaping early literacy practices. Emerging literature concerning this phenomenon largely focuses on the integration of these technologies into educational practice. The main conclusion that can be drawn from existing research is that tablets and apps have potential to support literacy learning only if they are supported with strong pedagogy and appropriate implementation. In this thesis I investigate how the design and features of app software play a role in the types of learning and outcomes that a tablet app may stimulate and how certain functional properties of applications align more closely with specific pedagogies, learning theories and literacy goals. The intent of this this is to explore how the design of educational literacy apps is related to or disconnected from learning theories and literacy development research. Conceptual prototyping is then used to ideate some potential ways designers may incorporate theories and findings into the functional design of possible applications. This work intends to communicate a designer's perspective and response to existing research through the process of literature review, an informed design method and prototyping. This will provide information to educators about what to look for in a saturated app market, as well as demonstrate to designers some of the ways they could make the most of mobile learning for this group (McQuiggan, McQuiggan, Sabourin & Kosturko, 2015).

1.1 Personal Perspective and Project Background

This thesis began as a result of a separate app development project named *Talking Books*. In that collaborative project, fellow researcher Emile Drescher and I sought to create an educational iPad application that was aimed at supporting reading development. The app targeted young children and used speech recognition to have users audibly read a narrative text in order to progress in a story. Some preliminary investigation was undertaken in order to justify the development of the project, and although some research supported the idea, much more contentious information about the surrounding area of iPads for education and literacy development was identified. As a design student, much of this information was foreign to me and in that instance, as an app designer, I found myself to be uninformed about how children learn to read and how I should design a product to support that learning. This was my personal motivation in undertaking this masters research project. The process of researching has led me to rethink my understanding of what is, and what is not, 'educational'. It has also led to a more informed approach to design, shown in this thesis through ideation and conceptual prototyping. The combination of the literature review, and conceptual prototypes come together to explain and demonstrate how an app can be better designed to facilitate literacy learning for children.

1.2 Method: How and Why I Went About it

To go about this process, I first investigated what type of applications have already been created, collated what I could find from researchers about these apps, and used that information to identify what was missing from my design process. I then used that information to ideate two conceptual prototypes.

I wanted to understand what factors contribute to an app being a good educational product, and how those factors relate to the design and development process. I also wanted to investigate how an app's features, functions and systems affected learning content and educational value. To do this I looked into what types of apps were being made and what research said about them. I chose to look at categories of apps, general critiques and design guidelines rather than researching single apps and reviews as they tended to be limited in scope, and could quickly be made redundant. Looking more broadly at app design trends allows conclusions to be drawn about general design process and may be extended to future applications. It is also provides a way to address the development and update rate of apps.

To determine what type of applications were commonly being made by developers I looked to Appstore reports and categorisations made by researchers and reviewers. I looked at the various ways the Appstore, researchers and review sites distinguished between different applications and combined these categories into my own system. I chose to develop my own categories for applications that identify apps by features and functions. I generated these categories because developing an app from a design perspective requires making a system to deliver content, and many current categorisation systems distinguish primarily by content first. Existing categorisation systems had little description of what features an app in that category should contain. I wanted to improve these categorisations by expanding on them with a focus on features and functions as the primary identifier.

The literature review was conducted through web search functions to find articles about the specific types of apps I had defined as relevant to the project as well as to locate general information about early literacy and tablet use. There is a wealth of information surrounding this area and to focus the project I concentrated on papers that related app design and learning. I narrowed down papers and authors by cross referencing and comparing citation counts to find the most relevant and authoritative figures in this area. An investigative literature review has been undertaken to inform the researcher of different learning theories and literacy teaching methods that are prevalent in research and educational practice. This was done to identify the target learner's needs and the different ways they are met, as well as to inform the researcher about definitive attributes of different theories and teaching methods. Chapter 4 presents an overview of learning theories and theories that were selected based upon their prevalence in instructional design methodologies.

In Chapter 5: Revisiting ideation and prototyping, the revised design method I utilised based upon the ADDIE model is discussed and applied. The ADDIE model is an instructional design model that consists of five phases - Analysis, Design, Development, Implementation, Evaluation. In this paper the first two phases are explored with particular attention paid to learning theory and ideation. Concept prototyping is used here to highlight the ideation phase of design the way an app idea is formed and how features and functions are derived are inherently related to how that app performs as an educational tool. Features of both applications are derived from learning theory and associated teaching methods. The reason why specific features of the applications are included and how they are derived from learning theory is included in the prototype section. The two conceptual prototypes presented - *To the Moon and Back* and *mARker* demonstrate a revised, more informed, design-led approach to educational app development. This thesis only focuses on the ideation of possible solutions to fulfil design criteria, rather than a full development cycle and the idea prototypes presented are examples which may, in the future, be taken through to fully develop, test and analyse as working prototypes.

Chapter 2 - Tablets, Apps and Context

The use of iPads, tablets, smartphones and other mobile touch screen technologies has become a ubiquitous aspect of modern daily lives. The proliferation and popularity of these devices can be attributed to their highly engaging interactive features, media content, relative affordability and variety of applications. As children read, interact and view content on these devices it has become evident that digital technologies are shaping early literacy experiences. There is no doubt that these devices are engaging to use, however, many parents and educators have expressed concern over digital technologies' place in childhood and learning. The varying presence of, and perceptions about, tablet use by young children is an emergent

theme in literature, yet no definitive position about the viability of their use has been reached. As a result, iPads, tablets and apps are and are not being used in childhood settings because of perceptions about the devices' benefits and detriments to children's learning, development and play.

A wide range of technologies and ICTs have been present in children's lives for a significant amount of time. Generally, a technology will first become embedded in wider social, economic, and cultural practices of adult life then later be used in educational contexts with children. This process has occurred with both analogue and digital technologies. Music records, cassette and CD players, televisions, slide projectors, overhead projectors, cameras and tape-based video cameras have all been available in preschools for many years (Dezuanni, Dooley, Gattenhof & Knight, 2015). Digital computing technologies became accessible to early educational environments in the 1990's, with 'learning software' and programs designed specifically for younger audiences. In recent years other digital technologies such as interactive whiteboards have also been introduced in many preschools (Dez et al., 2015).

The integration of technology and ICTs into early educational settings is not a new phenomenon, and smartphones, tablets and apps could be viewed simply as the next iteration in this cycle. However, in the past few years mobile devices, touch screens and wireless internet integration have made digital technologies, media and software highly accessible and increasingly commonplace in daily life. ICTs have been used by children for educational purposes for decades, but in comparison to older technologies (like the desktop computer), new mobile touch devices have been adopted much quicker (McManis & Gunnewig, 2012).

Digital technologies have become significant in the lives of most young children today, and new platforms and content for young children are arriving all the time. The current generation of young children are growing up in a digital media-saturated environment in which they receive daily exposure to a variety of technologies (Hisrich & Blanchard, 2009). Television, DVDs, mobile games, YouTube clips, motion-detection platforms like Kinect, digital cameras, Skype and FaceTime - each of these technologies and more are making their way into the households and daily routines of families with young children. Children today have an unprecedented level of access to sophisticated technologies (McQuiggan, McQuiggan, Sabourin & Kosturko, 2015), which in turn creates many more opportunities for children to observe, explore, and play with technology (Ihmeideh, 2014). Tablets, e-readers, and smartphones are prevalent ICT choices for many citizens (Rideout 2011). Studies around the world have highlighted the growing presence of touchscreen technologies in children's lives and the usage and uptake of devices like the iPad is now an emergent theme in educational research (Verenikina & Kervin, 2011).

The growth of availability of touchscreen devices has caused some concern about the type of content accessible by children, what activities are appropriate and whether or not the use of apps can be beneficial to a child's development. The immense variety of content being produced by independent sources creates varying degrees of quality, suitability and appropriateness. Many researchers, teachers, policy makers and parents have expressed a need for more information concerning the use of digital medias for educational purposes, yet only a small amount of research has been performed on the specific effects of app use by young children (O'Hare & Cinekid, 2014). While a thorough analysis of each individual application submitted to the Appstore and Play Store would help many educators, it is both difficult and time consuming to keep pace with their production. Apps may update, upgrade or be replaced much more quickly than research can usually be done. Also, as Robb (2010) points out, electronic media have changed and evolved so quickly in comparison to older technologies, that it is difficult to define their properties in a methodical manner, making it difficult to research the effects of a specific medium in a meaningful way.

Despite this, touchscreen technologies like the iPad have already been integrated and used as educational tools in many early childhood settings. There are some broad guidelines and philosophies concerning using the iPad in these environments, but these guidelines can be ambiguous and mostly emphasize that educators should be proactive in their understandings of digital technology, undergo some form of professional development and analyse technology on a case by case basis (Oldridge, 2010). Many researchers come to the same conclusion regarding software and technology use in the early years, which is summed up well by The National Association for the Education of Young Children (Radich, 2013, pg.4) - "*Technology and media are tools that are effective only when used appropriately. by educators who are grounded in child development theory and developmentally appropriate practices that have the knowledge, skills, and experience to select and use technology tools and interactive media...*" The main conclusion to be drawn from research is that effective learning through digital technologies is dependent on how educators and parents view and implement the technology at hand.

While the need for educators to understand these newer technologies is no doubt important, applications submitted to the Appstore are often marketed as educational, with little to no assurances of educational value (Vaala et al., 2015). This can be misleading for parents and educators who purchase or download these products under the assumption they will be beneficial to their children and students. Apps branded as being educational are seemingly created without due diligence which can leave teachers and researchers to assess an overwhelming number of apps of varying quality and content. In some instances, teachers are having to spend many out-of-school hours searching for appropriate apps to support learning objectives, taking away a considerable amount of their time (Flewitt, Messer & Kucirkova, 2014).

For parents of children that may lack the necessary knowledge or training, this task of assessment and purchasing decisions is made all the more daunting. This common uncertainty in average consumers has also resulted in the appearance of numerous review sites dedicated to children's apps. The question of whether or not the 'iPad', 'tablets', 'this app' or 'that app' is good or beneficial for a child has become a frequent query.

2.1 Tablet Features

The widespread adoption of tablets, and in particular the iPad, can be attributed to the device's capabilities, portability, interactive features and large range of engaging content. Tablets merge multiple technologies together into one device that is both intuitive and versatile in use. Their features enable the device to be used for many different purposes by many different user groups. Digital technologies like tablets also allow processes and activities to take place on far greater scales than before, in far quicker and more powerful ways yet occuring on smaller and more obtainable devices (Selwyn, 2011) . What a device is able to do and the specific features it has that enable it to do so are often referred to as 'affordances'. The affordances of a device will impact how a user interacts with it, how accessible it is, and how useful an audience will find it (Robb, 2010). The iPad has some affordances that make the device particularly attractive for early years learning (Lynch & Redpath, 2014).

The iPad's touchscreen interface invites a more tactile, fluid and mobile interaction which children can easily understand and access. The biggest difference between computer based software and tablet based apps is the use of multitouch gestures instead of mouse clicks. Most of the early critique surrounding the use of computers for educational content was related to how children interacted with the hardware. A mouse, keyboard and screen was often seen as being too complex an interface for a young child to operate. However, the size, portability and interaction capabilities of the iPad device are more intuitive and accessible than a desktop computer and more closely mirror traditional book reading experiences. The tablet's lower barrier to entry and accessibility are other key reasons children are so adept at using them. Touching, tapping and swiping with a finger are already actions that children employ whilst interacting with other physical objects. Many researchers remark on the ease of which children interact with touchscreen devices. Dezuanni et al., 2015) note how touch-screen apps seem to invite more direct interaction with children than software on a traditional computer.

The iPad's camera is quick and easy to operate. It's single touchscreen button interface and auto adjusting features means that children can very easily take a picture and review it in seconds. The camera can also be accessed by software running on the iPad which allows photos to be used in different ways. Likewise, the iPad's microphone can quickly be used to store sound bytes and can be used in conjunction with the camera to create and store videos.

The iPad's portability, size and weight is a key component of why the device has become so popular with children. Unlike desktop computers, tablets are lightweight and are not encumbered by cords, keyboard or a mouse which fixes desktops to one set location. Even though laptop computers are generally much more mobile than desktops, they are still most effectively interacted with at a desk, and may be cumbersome for children to carry and use. iPads and tablets on the other hand, may be picked up and operated by children with relative ease in almost any space or setting.

It should be noted that there are multiple models of iPad. The differences between these models mostly comes down to processing power, screen resolution and camera quality. There are slight differences in physical size across the standard model as well as a smaller iPad mini model and larger iPad Pro model. The first iPad did not feature cameras and the latest iPads, (iPad Air 2 and beyond) feature a touch ID scanner. Other than these changes, the iPad's capabilities and design mostly remain consistent. Android tablets made by other companies can vary extensively in terms of features. However, in addition to the touch screen interface, all of these tablets can access the internet and download software, most feature cameras and all range in processing capabilities.

Ultimately, tablet's various affordances all come together to deliver software packages that can be interacted with through the touchscreen, camera or the microphone. These programs are called applications, or 'apps' for short. When operating a tablet or any device running a mobile operating system (Apple's iOS or Google's Android), a user will either be navigating through a homescreen of apps or directly using an app. The biggest draw of the iPad and other tablets is the large range apps that are able to be downloaded and used on the device. Just like software on a regular computer - apps can vary dramatically in purpose, function and design. What an app is able to do and what it looks like is dependent on the developer who constructs the app. On the iPad, software may only be downloaded through the Appstore - Apple's digital, software storefront, and on an Android tablet apps are mostly downloaded through Google's Playstore. For a developer to publish an app on either of these platforms they must have the proper account and make sure that their app adheres to that platform's guidelines. This makes both the Appstore and the Playstore fairly open marketplaces and allows for a diverse range of applications to be produced by practically any person, team or company with the technical know how.

Chapter 3 - Categorisation and Review of App Designs

There are over 80,000 apps in the Education category of the Appstore alone (Apple, 2015) which range across virtually all developmental levels. Developers are capitalizing on a growing market by creating a large variety of applications which are targeted at a young audience. Apps can be used in a myriad of ways to help meet traditional print-based literacy goals and also provide students with opportunities to learn new literacies. Many applications that target early reading skills share similar features and formats and may be grouped together by these functional properties. For instance, there is a very large range of Storybook apps which all have the same basic features but vary in terms of story, illustration and extra content such as additional colouring-in pages or narration options. The Appstore's own categorization of these apps is somewhat limited in that not every app is categorized correctly and broad identifiers like ‘educational’ can be misleading to consumers. Due to this, other categorization methods have been employed by researchers and reviewers. These categories of apps also reflect what developers are prioritizing as worthwhile products. Because apps vary so greatly, classification can difficult to narrow down and many experts find it hard to establish a good system because there often is a lot of overlap between categories (O’Hare & Cinekid, 2014). This section explores what types of apps are being made by developers, and defines a set of categories which are later utilised as the basis for collating information and reviews about that type of application.

Carly Shuler from the Joan Ganz Cooney center is often cited for her 2012 Appstore analysis where she found that under the education category, more than 80% of the apps were aimed at children. Furthermore, nearly three quarters of the bestselling apps in the Appstore in 2012 where aimed at children of preschool and elementary school ages (Shuler, Levine & Ree, 2012). In 2015 The Joan Ganz Cooney Center expanded on this study and published their findings from a thorough investigation into literacy-focused apps for children ages 0-8 years found on the Appstore. They separated apps by pricing model first and then expanded on different identifiers. They paid particular attention to well rated applications but also analysed apps along numerous dimensions - "including characteristics of their descriptions (e.g., number of words used to describe each app; target audience age-range; specific skills mentioned) and features within their actual content (e.g., the nature of adult-directed information; types of activities)", (Vaala, Ly & Levine, 2015). When they sought to categorise the features and activities found in applications they sorted apps into: 1. Storybooks, 2. Other narratives that were not books (e.g., video stories), 3. Games, puzzles, or quizzes , 4. Tracing activities (these mostly entailed tracing letters and numbers), 5. Coloring or sticker activities, 6. Songs, and 7. Tutorials or lessons (these were non-narrative presentations of educational information). An eighth category: "Other interactive activity" included other activities such as "creating your own storybook, recording video stories and sharing them, and various other user-generated content activities" (Vaala et al., 2015).

The Appstore organizes apps into two or three preset categories which are defined by keywords provided by the application's developers (Leeflang, 2015). These categories primarily organize apps based upon content and function. There are also sub categories and collections which contain more specific sets of apps, including some subcategories related to early literacy development. In the 'Early Years' section of the Appstore there is a 'Literacy' subcategory which is further split into four sections - 'Phonics, Words and Spelling', 'Print Concepts and Letters', 'Reading and Telling Stories', and 'Interactive books'. However, these subcategories usually only contain a small number of programs and many apps that should fall under these subcategories will not appear. In 2013 Apple also released a 'Kids' category which is further split into age subcategories: '5 & Under', '6 - 8' and '9 - 11'. In the '5 & Under' category there is a 'First Words & Numbers' section, as well as an 'Interactive Kids Stories' collection. In the '6 - 8' category there is also an 'Interactive Kids Stories' subcategory, but no other grouping directly related to literacy. It should be noted that these categories are all subject to change, may be updated or removed with time and can also be region dependant. The Appstore's limited categorical organization may not allow users to easily find apps that contain specific content or are of a specific format, because of this some companies, websites and researchers have created their own categories for assessment, review and development purposes.

In 2012, Lisa Guernsey and fellow researchers published a report in which they examined a number of popular early literacy applications on the Appstore, Google play store and on the review site Common Sense Media. Their categorization and selection criteria was based upon the literacy development skills applications targeted. Some apps targeted more than just one skill, but in order to be considered literacy focused the application must have targeted at least one of the following: “print concepts; letters and letter sounds; phonics with word recognition; vocabulary; letter writing; comprehension; the ability to understand and tell stories; spelling and/or grammar” (Guernsey et al., 2012).

Guernsey et al. (2012) also lists a number of app review sites and organizations that rate and categorize apps. These include Common Sense Media (CSM), Kindertown, Yogi Play, Children’s Technology Review (CTR), Parents’ Choice and Appolocious. Since that report more review sites have appeared such as Best apps for Kids, Best Kids apps, APPtic, Teachers with Apps, Reading Rockets, etc. The majority of these sites have basic categories of apps that are organised by age range. Reading Rockets, Children’s Technology Review and Common Sense Media have more extensive classification systems for literacy development applications. Reading Rockets, categorises literacy apps by different topics, which include: Comprehension, Dyslexia and Learning Disabilities, Multimedia Composition, Phonics, Print Awareness, Spelling, Vocabulary, and Writing (Reading Rockets, 2016). The Children’s Technology Review categorizes literacy development apps under the “Language Topics” heading with further sub-categories including: Decoding, Handwriting, Phonics, Letter Recognition, Reading, Storytelling, Writing, French and Spanish (CTR, 2015). Common Sense Media has a Language and Reading subject category which can be further split into age, media content and also what skill the application targets - Thinking & Reasoning, Creativity, Self-Direction, Emotional Development, Communication, Collaboration, Responsibility & Ethics, Tech Skills, and Health & Fitness (Common Sense Media, 2015).

SagoSago CEO Jason Krogh’s explanation of app categories closely aligns to functional properties of available literacy development apps. O’Hare & Cinekid (2014) summarises his explanation of categories as follows:

“-Creation apps (creative self-made as an end results, drawing apps, for example)
-Exploration apps (Here’s a world, non-linear, just look around, just explore)
-Assessment or feedback apps (Can be formal/ strict or very light touch, they present a challenge or puzzle, it makes judgments about the actions of a user)
-Simulation apps (Mimics real world play activity)
-Story/narrative apps (Closer to a book, clear beginning, middle and end. Every user has a common experience).”

3.1 Classification

I will be adapting the aforementioned classification systems to focus specifically on applications that target reading and literacy skills. From a design perspective, creating an app requires building a system to deliver content. Content such as videos, levels in a game, words in a story, animations, illustrations etc are usually created independently from the software development process and may be updated and changed later but still require a base system to be delivered in. For instance, creating an interactive book requires a substantially different set of features and functions than creating an open world game but both may contain the same characters, words, and illustrations. Reading development apps that share functional properties also often target the same literacy development skills or employ the same teaching techniques and because of this, researchers often comment about a specific type or category of app. For these reasons the following categories I use identify apps by their main features and functional properties. The categories are defined and in the next section I expand on what information is available about those types of app's in terms of educational effectiveness. This will allow me to compare, group and extend reviews and situate my own design process later on. The categories I have used are:

1. Book, Story and Narrative Apps
2. Game and Assessment Apps
3. Simulation and Manipulable Apps
4. Creation Apps
5. Augmented Interaction Apps

These categories are discussed further in the following sections.

Book, Story and Narrative apps

There is a large range of children's interactive storybooks which share similar features and layouts. Digital storybooks have been around much longer than the iPad and most apps of this kind follow established e-book formats. The shift to a digital platform can change the nature of a book reading experience depending on what features are added to the app. Storybook apps follow a page based structure with text, illustration, audio and animation unveiling more of a story as users progress through pages. Readers generally transition between pages through interactive turning gestures or button presses. Some other common features of interactive book apps include: narration, hotspots, word/picture labels, embedded dictionaries, literacy activities, music/sounds, text highlighting, animation, tilt/shake/turn device interactivity, voice recording, multiple languages, parental involvement functions, rewards, social sharing, 3D effects and camera use (Guernesy et al., 2012). A large number of storybook apps also have embedded mini games or tasks that are either part of the story and need to be completed in order to progress or they are side content that doesn't directly relate to the story but involves characters and other elements from the narrative. It's common to see find and gathering games, matching

tasks and colour-in scenes as side content. Some applications even contextualise story reading as a gamified experience where a user can amass points by making their way through various books. The varying degrees to which these elements can be used creates a spectrum of apps which range from a passive, linear viewing experiences which mirror traditional book reading to highly interactive, hypermedia laden e-books which can transition from story to game or activity and back seamlessly.

Most of the conclusions that have already been drawn from research about digital stories can also be applied to Book, Story and Narrative apps. Ihmeideh (2014) has collated many recent research papers about the effects of standard e-books on the development of children's language and literacy skills and has offered evidence regarding how this digital form of book helps promote different emergent literacy skills (De Jong & Bus, 2004; Gong & Levy, 2009; Maynard & McKnight, 2001; Moody, 2010; Neuman, 2014; Verhallen & Bus, 2010; Zucker, Moody, & McKenna, 2009). Storybook apps can help build vocabulary by exposing children to many different words that are used in an entertaining context which allows for better comprehension. Text highlighting can support comprehension, print awareness and alphabetic knowledge (Moody, 2010). Some apps also have built in dictionaries or visual representations of words which may aid comprehension even further. Well crafted stories and visuals can engage children and keep them motivated to continue on with a narrative. Pictures and animations support word recognition and comprehension (Doty, Popplewell, & Byers, 2001). Storybooks may also teach through their narrative, be it through fictional representation or factual recount. They may also directly or indirectly demonstrate how language can be used in different circumstances such as through conversations between characters. The text in the application could focus on utilising a set of words that contain particular phonetics, or perhaps use playful combinations of words to emphasize rhyme, spelling or storytelling.

Some examples include: I-Imagine (Bizzibrains Pty Ltd, 2016) , The Fantastic Flying Books of Morris Lessmore (Simon and Schuster Digital Sales Inc, 2012).

Game and Assessment apps

Games are by far the most popular category of applications downloaded from the Appstore. In terms of early literacy, the appeal of an application being a fun or playful ‘game’ also makes them a prevalent choice amongst children and parents alike. Unlike open play apps, games apps have evident goals which users must accomplish correctly or within a time limit. The category is named Game and Assessment apps because nearly all game applications for children around this age which focus on literacy skills are tests framed within game-like layers. Game and Assessment apps usually have different activities, levelled content, progression indicators, and virtual rewards. Many game and assessment apps will target a single literacy

skill and the types of activities found in that application are reflective of that skill. Other apps test multiple skills and similar activities can be found amongst them. Phonics, alphabet knowledge and spelling apps are the most common type of games to be found in educational categories of the Appstore. These apps have nearly identical features and resemble skill and drill type exercises. For example, letters could be show on screen which need to be arranged in a certain order to make a word. When a letter is tapped it will usually play audio of what that letter sounds like phonetically. When the word is arranged correctly there may be animation confirmation and visual elements usually relate to what word is spelt out. User's will cycle through words based upon their first letter or a particular phonetic sound. This model is used extensively in apps and the only difference between most of what is available is the words and visual elements that application chooses to employ. In other game apps users progress through levels and increasingly difficult problems which require correct answers in order to move on in the application. Correct responses are frequently rewarded by virtual reinforcements such as coins, tokens, points etc. Sometimes these rewards affect the user's interaction and progression within the game and come in the form of power ups, bonuses, unlocks etc. Incorrect actions and responses result in a loss of 'life', collectables or perhaps users may simply have to replay a level until the correct response is given. Intermittent and random rewards are also often used in these game-like apps as a way of keeping users engaged in playing and using the application.

Some examples include: Endless Reader (Originator Inc, 2017), ABCMouse.com (Age of Learning Inc, 2017) , Hooked on Phonics - The #1 Learn to Read Program (Sandviks HOP, 2017)

Simulation and Manipulable Apps

Simulation and Manipulable Apps encompasses most open play applications where users are presented content that they can interact with in some way. These apps don't have an explicit goal or task like a game app would, but rather show users a number of different things that they may activate for some sort of multi-media response. The most common example of this is the large range of interactive alphabet apps but also includes apps such as colouring books. These kinds of apps mainly differ in terms of their theme or art style. There are also a number of Simulation and Manipulable apps which may not feature any written text at all, but can be used as starting point for literacy teaching. These types of apps function more like digital toys than instructable content. They present digital elements that respond to touch and feature rich amounts of animation, sound and media.

Some examples include: AlphaTots Alphabet (Spinlight Studio, 2017), Toca Kitchen (Toca Boca AB, 2016)

Creation Apps

There are significantly fewer literacy focused, creator apps in comparison to storybook apps available on the Appstore, but there are still enough to have varying degrees of functionality. These apps let the user create their own media through the use of images, animation, text, audio, buttons and page transitions. In some applications this content are predefined and the users choose what to place on a select page from from a gallery of pictures, words, sounds or 'stickers'. These predefined elements usually relate to characters, objects and backgrounds. In other applications users may control features of the iPad in order to record and create their own content. This includes using the camera to take pictures; using the microphone to record their own audio bytes and narration; or using the keyboard to input words and letters into text boxes and speech bubbles. There are also some hybrid storybook/creator applications which feature a story and let the user alter select visual elements of the story. Some other apps present a narrative then allow users to create their own interpretation by using elements from that story.

Some examples include: Our Story for iPad (The Open University, 2015), Puppet Pals HD (Polished Play LLC, 2017), Strip designer (Egeblad, 2017)

Augmented Interaction Apps

The Augmented Interaction category encompasses apps that utilise hardware features of the iPad to augment the ways a user can interact with the tablet, environment and other people. This primarily means using the cameras and microphone to record or stream media. Apps of this type differ from Creator apps in that their primary purpose isn't to make something tangible or virtual, rather they may facilitate communication between people and multiple devices, or allow content to be interacted with in a different way. There are a number of these applications on the market but not many are early literacy focused. Also, some applications in this category are too complex for younger children to successfully operate on their own and must be used either in conjunction with or under supervision of an adult. There are some apps which feature digital characters that children can "talk" to, which may be used as a conversation teaching tool, or simply as a playful repetition exercise.

Some examples include: Alien Assignment (Fred Rogers Center, 2012), Storytime: Read with your Kids over Video Chat (Kindoma Inc, 2017)

3.2 Receptions and Remarks from Research

Apps are often tested and reviewed by different measures depending on what that application targets. Apps can and have been assessed individually for their educational value since developers started making educational claims. Reviews can help consumers choose and distinguish between applications before purchasing and downloading. However, the sheer number of applications present and the pace at which they may change, upgrade or update can make many of these reviews obsolete in the time that they can be published. Instead of single specific reviews, some researchers have taken to commenting more broadly about app design, or about specific categories of apps such as those defined earlier. The next section explores guidelines and critiques of apps to ascertain what general aspects of app design developers need to improve on to deliver better educational products.

Here I will focus on remarks that relate specifically to the design of learning systems. Interface is an important aspect of app design but it's purpose is to effectively deliver content or allow users to navigate an underlying learning system. There are numerous guides and comments about interface design of apps and how elements should be sized, coloured, laid out etc. In summary these suggest interactions should be simple and intuitive and "touch functions and buttons should be scaled to the users' expected fine motor skill level" (McQuiggan et al., 2015). Other aspects of reviews and design guides reaffirm the use of appropriate media and visuals which are suitable for a young audience and contain characters, elements and settings they would be able to relate to (O'Hare & Cinekid, 2014). Monetisation is also another big concern and can become a problem when in-app purchases and advertisements infringe upon learning content or when a challenge is designed in such a way that a user can pay to win. Software development is a costly process and consumers should expect to be charged for quality content, but apps directed at a young audience should also implement child friendly pricing models which don't interfere with learning content. These are all important factors but only become an issue when they affect the underlying learning system of an app which is what the following concerns focus on.

Four key design features are consistently brought up in guidelines and reviews concerning the system design of literacy learning apps. The first is that there is a balance to be struck between user engagement and learning content. The second is that apps should take care in how they handle users time. The third is that not enough apps focus on including parents and teachers or encouraging social interactions. The fourth is that apps aren't designed with concrete learning goals or research backed understandings of learning.

Most apps are inherently engaging experiences for children and good apps utilise engagement to keep users' focus on learning content. Children develop faster when they are actively engaged with media (O'Hare & Cinekid, 2014), but an overabundance of interactive features can detract attention away from learning content. While the positive effects of simple e-

books have been proven in many separate tests, the extra layers of interactive media on top of these base functions have been met with much more criticism. Interactive ‘hotspots’ are one of the most common additions to book, story and narrative apps and allow for elements on screen to respond to a touch gesture. For example, clicking or pressing on an image of an airplane could make it fly around the screen. Robb & Lauricella (2014) researched the effects hotspots and found they can either enhance learning when they are congruent and central to the storyline or can hinder learning when they are distracting. Similarly with Game and Assessment apps, the way activities are designed and implemented has “crucial implications for how children engaged with them and what they got out of them” (Vaala et al., 2015). Motivating children to progress and work through problems with game-like features can keep them engaged with an app but the desire to win and obtain rewards can overshadow the learning goals (Falloon, 2013). There is a fine line in balancing features here and whether or not an engaging element helps or hinders comes down to why a designer includes that feature in the first place. If the designer intends the application to be focussed on having educational value then features should only be included to reinforce learning and extraneous graphics, hotspots, animations and other elements should be removed if they don’t relate to a learning goal (McQuiggan et al., 2015).

When designing an application for children retention and usage time are important design factors. Some applications like Toca Boca’s range of open ended digital toys can be picked up and played with for any given amount of time, at any time of the day. There is hardly any delay in getting into the main functions of the app and users can get to play right away. In most creation, simulation and manipulable, and augmented interaction apps there are no time or point pressures placed upon users, so they can leave and stop using the application at any time. Similarly book apps can be started and stopped at any time. Although it may be alluring to finish a short story in a single session, users can just as easily pick up from the page they left on. Children using these apps can review particular sections over and over again for enjoyment or for comprehension reasons. Applications like these can fit into any time schedule and may be used for just a few minutes at a time. Conversely, the design of many game applications encourage users to play for longer sessions and to frequently return to that application. These apps usually do this through having limited level attempts, strategically rewarding resources that allow users to keep playing, having timed levels or emplacing restraints on when you can do certain activities. Restricting progression like this could increase frustration and demotivate children to continue to play, or prevent children from accessing specific educational content (Robb, 2010). When designing content and challenges developers should be mindful of pacing. Instead of overloading an app with constantly changing media and enforcing time limits an app should be able to be worked through at any pace and be responsive to the child’s actions.

One of the most prominent concerns about children using digital media at a young age is screen time. The foremost authority on this subject - the American Academy of Pediatrics -

updated their recommendations in November 2016. For children under 2 they discourage any use of screen media other than video-chatting. For children ages 2 to 5 years, they recommend limiting screen use to 1 hour per day of high-quality programs. For children ages 6 and older, they recommend placing consistent limits on the time spent using media but highlight a bigger concern on what type of media is being used. All of these guidelines stem from supporting children's health in terms making sure they are getting adequate sleep, enough physical activity and other engaging in other behaviors essential to health.

The same guidelines by the American Academy of Pediatrics also highlight that digital media should be used together with a parent or guardian. Research has shown how the role of the parent or teacher is still vital in developing literacy skills and shouldn't be diminished or replace with digital tools. Children have proven to learn more from digital media when parents or other adults are involved in joint-media engagement (McQuiggan et al, 2015). Parents can help children break down what they are seeing on screen or provide tips or scaffolds to help them progress in an app (Robb & Lauricella, 2014). Most available apps do a fair job at engaging users and using developmentally appropriate content but do not do enough to cater to the social context of app use by young children and adults (Naranjo-Bock, 2017).

Hisch-Pasek et al. (2015, pg.5) describes the current app market as the "first wave of app development" where games and learning scenarios (that already exist in nondigital form) are just ported over into apps. Most designs are simple tasks that reflect familiar formats and only offer closed literacy experiences designed for passive recipients (Lynch & Redpath, 2014). While every bit of technology has potential to be used positively in educational environments not every tool or technology is created equally. Not every app is as beneficial for the development of a child, as is the case will all kinds of products and media (O'Hare & Cinekid, 2014). Multiple factors point to a disconnect between the apps developers are making and the perceived needs of the children these apps target. A number of researchers have commented on the relationship between designer and content. Chau (2014, pg.49) stated how "an examination of what content is good must begin with an understanding of the developmental needs of children". Similarly, on the topic of digital storybooks, Paciga (2014) noted how in order for interactions to be meaningful and developmentally appropriate activities for young children – activities that are connected to literacy outcomes – it is important that we understand the variables at play and how they relate to one another. Likewise, Hirsh-Pasek et al, (2015, pg.25) stated that for developers to produce a good educational application "it is critical for them to examine the literature on how to best frame the content so that it is consistent with scientific evidence." Only a handful of apps are designed with an eye toward how children actually learn (Vaala et al., 2015).

3.3 Chapter 3 Summary

Comments about these four areas reflect a fundamental disconnect between designer intent and understandings of the learning process. Too many apps assume that a child is going to automatically learn through engaging with their content (Robb & Lauricella, 2014), rather than using that time to foster social connections and other researched backed methods of supporting learning. The design and features of app software play a significant role in the types of learning and outcomes that a tablet app may produce and many apps' features are falling short of their advertised 'educational' benefits. App designers have the opportunity to create applications for children that support the learning process if they base their app ideas on proven understanding of learnings and make sure to carefully consider how each element they include into an apps design relates to that theory of learning.

Chapter 4: App Design and Learning Theory

An app's features are often dictated by developer's priorities, intent and process. When designing children's reading apps, developers may be looking to make a profitable product; they could be iterating on existing designs with new content; they may be testing out their own skills or an idea they had; or they could be looking to genuinely support the development of reading skills. These are not mutually exclusive priorities and it is important to note that apps are usually developed by teams of people, each with potentially with different agendas. As app development has become an established industry it is increasingly commonplace for apps to be commissioned for development by separate people, organisations or businesses. So, people involved in creating an application might be creating it to tick off a set of objectives and earn a paycheck. Without individually interviewing every developer it is impossible to garner exact intentions and determine why certain features are implemented.

As a designer what I can speak to is how, in app development, the initial process of ideation often lacks a grounding in learning theory. This thesis began as a result of a separate app development project named *Talking Books* (which was undertaken in 2015). In that collaborative project, fellow researcher Emile Drescher and I sought to create an iPad application that was aimed at supporting literacy development. The genesis of that idea came from wanting to merge together forms of tablet interaction with media playback in order to adapt the storybook experience. The app targeted young children and used speech recognition to have users audibly read a narrative text in order to progress in a story. Words on a page would have to be read out aloud before progress could be made and animation would trigger on user's correct enunciation. In this instance as a designer I approached the project with a preconceived idea about how children learn and believed that this direct assessment system would allow users to develop phonetic and vocabulary skills through a repetition and mastery approach. According to Hirsh-Pasek et al, (2015) this seems to be a common trend amongst designers and apps are influenced more by current trends, designer's personal interactions with technology, and their experiences and intuitive sense of how learning happens or what children will find enjoyable. Rather than looking to research and science as a starting point for the ideation and development of the Talking Books app, some 'evidence' was only used later on in the project to justify the idea rather than to inform it.

To develop the *Talking Books* application we used an Agile software development methodology that focused on rapid prototyping and iterative design cycles. Software development methodologies like Agile focus on creating functional parts of software in short time intervals so that they may be tested and analysed in working conditions with potential user groups and stakeholders. These software prototypes are then evaluated and refined to be tested again in iterative development cycles. For *Talking Books*, this methodology was able to produce notable developments in terms of working prototypes and app functions. However, as the project progressed, I uncovered more information regarding apps and early literacy

development which contradicted the base idea behind the app. In this instance, using an Agile methodology did succeed in creating working prototypes that were tested with potential users, but ultimately failed to produce results which met the educational goals of the application because it did not do enough to identify the problem, the users, their needs and apply theory in the ideation phase. While Agile was developed specifically to allow for changes in the design process, I considered that the fundamental idea for the application did not meet best practices of learning theory and early literacy education. Even though many developments and iterations had been made, and could still be made, there was a crucial disconnect between the app concept and learning theory. This is commonly referred to as a "waterfall" design problem, (Rimmer, 2016).

Instructional design methodologies focus on how to best implement learning theory and design instruction so learning will take place. Because the Talking Books project was focussed on creating an educational product I realized it would be more appropriate to use an instructional design methodology rather than just software development methodology. Instructional methodologies have a greater emphasis on a pre-analysis of learners in order to locate and situate the project. For instance, the ADDIE model (analysis, design, development, implementation, and evaluation) specifically asks "what are the pedagogical considerations?" and "what learning theory considerations apply?" in the very first step of the method. Instructional goals, success metrics, and overall objectives are also established early on as a basis for the project. Ideation and design extend from these prerequisites and content, storyboards, learning objectives and instruction methods are defined after. Some models like SAM (Successive Approximation Model) even take into account Agile methods and utilise rapid development cycles to reinforce the creation of working prototypes but still retain the import initial steps of user assessment and incorporation of learning theory.

4.1 Learning Theories

Educational apps and technologies are explicitly or implicitly designed around theories of learning. If an application is marketed as educational or purports to help children learn it will look to deliver or teach content in a certain way. How that application attempts to deliver or teach is reflective of how the creators believe users should learn or play with content. Most apps wind up being an eclectic mix of theories that are, in themselves, continually adapting and not cast in stone (Buckleitner, 2014, pg.59). Learning theory is a well established area and has influenced design decisions in educational products since their conception. Over time, multiple theories of learning have emerged and developed on one another. Learning theory has been a contested scientific field for most of its history, with contributions from many scientific disciplines, practices and policy positions. Over time the definition of learning has changed in response to theoretical shifts in psychology (McQuiggan, McQuiggan, Sabourin, & Kosturko,

2015). Understandings of learning have shifted from “learning as a behaviour that can be controlled by external events; learning as individual cognitive activity; and learning as a social construct” (Cullen, 2001, p. 13). These theoretical positions are respectively referred to as Behaviourism, Cognitivism and Social Constructivism, with other theories of learning generally extending from these three paradigms. The following section examines these three major perspectives, their origins, developments, important theories and how they may relate to app design. Note that this an intentionally simplified summary of the field but, for the purposes of this thesis, is adequate for identifying and differentiating between design influences. Those well versed in educational practice will have a broader understanding of these concepts as opposed those who only practice software design. The intention of this section is to briefly summarise different learning theories and teaching methods so designers can get a better of the major separate ideas about learning.

Behaviourism

A number of different scientists have researched the process of learning and have developed theories to explain how it occurs. John. B. Watson is regarded as the father of Behaviourism and was the first to introduce the term in 1913. He outlined a focus on external, observable events rather than internal mental processes. Behaviourism identifies a learner as a blank slate and defines development as a change in perceivable behaviour. A person’s behaviour is molded through their interactions with the environment and stimuli. Learning, therefore, is described in terms of stimulus and response and can be molded through conditioning, of which there are two primary types: classical and operant.

Classical conditioning was first introduced by Ivan Pavlov as means to explain a learned behaviour he noticed in his experiments with dogs (1927). He discovered that dogs began to salivate upon hearing a tone that was previously played when the dogs were given food. He suggested that the dogs had associated the neutral stimulus (tone) with an unconditioned stimulus (the taste of food). The tone could be played by itself and the dogs would salivate, meaning that the tone had become a conditioned stimulus which resulted in a conditioned response. Classical conditioning mainly deals with reflexes and involuntary behaviour. Many argued that this theory could not account for all aspects of learning that were evidently occurring.

B.F. Skinner introduced the idea of operant conditioning to explain a wider range of learning in 1936. Skinner posited that behavior may be shaped through reinforcement and punishment after a behaviour occurred. Desired behaviour is met with reinforcement, such as reward and praise, encouraging the learner to repeat that behaviour. Whereas undesired behaviour is punished, through responses like scalding or removal of privileges, discouraging

the learner to repeat that behaviour. Punishment and reinforcement can be either positive (applying a stimulus) or negative (withholding a stimulus).

Operant conditioning developed on the early ideas of Edward Thorndike (1932). Thorndike's law of effect highlighted the importance of immediacy of responses to behaviour. Reinforcement or punishment must be contiguous with behaviour in order for a learner to associate a response to a stimulus. Rewards or punishments can be applied in a number of ways and the amount and timing between receiving rewards can be used to motivate a subject to continue a behaviour. Intermittent rewards for a specific behaviour were found to increase a subject's will to repeat an action or behaviour, rather than rewarding immediately after every instance of an action or behaviour.

As Falloon (2013) noticed, most apps marketed as educational are game-like in form and are designed to consolidate and practice learnt knowledge and skills which generally reflects a behaviourist view of learning In current literature and policy Behaviourism is not a popular theory of learning, and its ideas are not commonly implemented in professional educational practice. Behaviourism does have benefits for rote memorization of facts or smaller bits of information but starts to fall off in effectiveness when more complex concepts are being taught (Simmons, 2006). It is generally not a recommended strategy for long term learning and development in most educational settings. However, many principles about behaviour management and skill learning are heavily applied to the design of educational games. Edutainment games and educational software for children regularly employ 'skill and drill' type exercises that reward and punish behaviour. Reeve (2012) has recognized that "computer games are sometimes described as a 'Skinner box'," as "many games require the performance of a repetitive task to achieve some goal or reward," just like Skinner's experiments.

Cognitivism

In the mid-twentieth century studies were published that challenged the dominant Behaviourist models of learning. Research showing instances of learning occurring outside of behaviourist models began to accumulate. These studies mainly detailed how learning could occur without strict conditioning or external reinforcement. They also showed how learning could happen indirectly, or relatively instantaneously.

These various studies ultimately put forward a theory of mind distinct from Behaviorism. Instead of viewing the human mind as blank slate, cognitivism views the human mind as flexible, self-adapting, and, in many respects, self-taught (McQuiggan, McQuiggan, Sabourin, & Kosturko, 2015). This notion developed into the understanding that internal processes of the mind drove learning and development, rather than external stimuli. This understanding of the

mind is now the dominant theoretical perspective in learning theory and cognitivist perspectives expand upon this premise of internal development. Four key cognitivist theories of learning are explained under the following headings: Social Cognitive theory, Constructivism and Sociocultural Constructivism.

Social-Cognitive Theory

One of the theories that initially posed a challenge to Behaviourism was Social Cognitive theory. It was developed during Behaviourism's dominance and may be seen as a midway point towards Cognitivism. A number of researchers observed how learners may acquire new behaviors and knowledge through indirect means. Instead of learning through direct reinforcement or punishment, social-cognitive theory states that people are able to learn behaviours and knowledge by observing a model.

A model may be a live or symbolic. A live model is a person who demonstrates behavior that is observable in real life. A symbolic model may be a real person or fictional character that is portrayed indirectly through media, books, etc. Learning occurs when an observer sees a model be reinforced or punished for a specific behaviour, or after demonstrating knowledge. An observer can then translate that experience of the model to their own actions and may repeat of refrain from a certain behaviour even if they are not rewarded or punished themselves.

This form of learning is not direct as in Behaviorism, and it raised questions about the nature of learning. Social-cognitivists defined learning as an internal process that did not necessarily occur immediately in reaction to a stimulus. Reinforcements and punishments were seen to have indirect effects on learning and behaviour. Rather than responding only to a present situation, people were seen to develop expectations and perceptions about how certain responses to stimuli would be received. They also acknowledge how this process of observation, reflection and internalization was more self regulated than the learning that was taking place in Behaviorist experiments.

Piaget's Theory

Jean Piaget was a Swiss psychologist whose studies and tests with children led him to develop the field of genetic epistemology, which is concerned with the origins of knowledge. He believed that cognitive development extended from internal, biological, mental processes and learning occurred as a result of interactions between learner and environment. He proposed that children are active learners who construct knowledge and develop schemata through the process of assimilation and accommodation and that more complex cognitive development

occurs through equilibration. He also theorised that these processes of constructing knowledge occur in defined, maturational stages and that cognitive development precedes learning.

Defining Learning: Schemas, Assimilation, Accommodation and Equilibration

Piaget (1952) defined a schema as a cohesive, repeatable action sequence possessing component actions that are tightly interconnected and governed by a core meaning. In simpler terms, a schema is an organized set of elements which create a mental framework that represent a unit of knowledge. These schemas allow people to understand, classify or respond to situations. Children mostly have simple schemas that allow them to classify and respond to objects, actions and abstract concepts.

When a child is exposed to new situation, they may interpret and respond to that situation in a way that is consistent with an existing schema. This process is called assimilation. Assimilation allows a person to quickly gather, access and assess information about a situation. In Piaget's view, cognitive development occurs through creating new schemata or extending and altering current schemata. This process is called accommodation, it allows new information and situations to be mentally processed.

Constructing new schemata, and adjusting information to fit within existing schemata occur when a person cannot make sense or appropriately respond to a situation. When this happens, a person is said to be in a state of disequilibrium and uses accommodation or assimilation to readjust their understanding. Equilibrium is when most things in the learner's environment can be understood through existing schema. Piaget argued that Equilibration, the process of moving between states of equilibrium and disequilibrium, is what drives mental growth. And that together, assimilation and accommodation allow children to learn quickly and with greater complexity.

Active Interaction with the Environment:

Piaget believed that children are active and motivated learners who seek to make sense of the world around them through engagement and interaction. The child can be seen as taking an active role in forming their own interpretations of how they see the world (Piaget, 1967). It became evident that the experiences learners had in their physical and social environment and how information from those experiences was perceived is extremely influential on how knowledge, or schemata, are constructed. Piaget posited that children's engagement with the physical environment, through experimenting and manipulating objects, was integral to early development. He also highlighted how the social environment allows for multiple perspectives, opinions and approaches to a task or event. In summary, information is gained through

interaction with the environment but what is learnt is dependent on the environment itself and how it is interacted with, as well as the knowledge that is brought to the situation (Gauvain, 2001).

Stages of Development:

Piaget was also influenced by Rousseau's and Montessori's maturational stage theories of development (Crain, 2004). He believed that a child's capability to process and understand information was dependent on biological maturation through sequential development stages. In his view development was not simply acquiring more knowledge and developing schema, but rather how a child is able to think and processes information changes over time. Piaget closely studied the progressive changes that children went through in both behaviour and thinking at different stages in their development (Piaget & Inhelder, 1969). He believed that the environments, artifacts and interactions presented to children to engage with should be appropriate for their developmental stage (Oldridge, 2010). Piaget approximated rough age ranges for each stage of standard development. The stages are: sensorimotor stage, preoperational stage, concrete operations and formal operations. As this thesis focuses on early literacy development of children from the age of 3 to 7, the pre-operational stage is the most important to examine.

Sensorimotor Stage

The sensorimotor stage occurs from birth to approximately 1-2 years. During this stage, infants and toddlers acquire knowledge through sensory experiences and manipulating objects. At this point in development, a child's intelligence consists of their basic motor and sensory explorations of the world. Object permanence or object constancy - the understanding that objects continue to exist even when they cannot be seen, is a key area of development in these early years. Learning that objects are separate and distinct entities which have an existence of their own outside of individual perception enables children to be able to begin to attach names and words to objects.

Preoperational Stage

The Preoperational stage occurs from around 2-3 years to approximately 7 years of age. The use of language and logic begin to develop in the preoperational stage. Language use develops from basic classifying and labelling of objects to more conversational and expressive communication. Logical understandings develop from single criterion deductions in a given situation, towards beginning to recognise basic logical relationships and applying concepts to multiple situations, such as using number or grouping by colour. These language and logic

developments allow children to be able to symbolically represent and understand through mental images. Mental constructs are usually limited to the child's own perception and experience as they are unable to perceive another's point of view, meaning they are very much egocentric. During this time, children have difficulty distinguishing between fantasy and reality. This stage is also often marked by curiosity and inquisitiveness. With the development of language children are able to ask more about the world around them which also enables them to be more social.

Concrete Operational Stage

The Concrete Operational stage takes place between roughly seven and eleven years of age. Children at this stage begin to think more logically and can apply logic to physical objects and situations. However, abstract, hypothetical and complex thought are still a struggle. Logical and cognitive development allows children to be able to discern between fantasy and reality. Also, children become far less egocentric in this stage. They are able to consider another person's point of view and may better understand their own and other's emotions.

Formal Operational Stage

The Formal Operational stage occurs from about eleven onwards. The final stage of Piaget's theory involves an increase in logic, the ability to use deductive reasoning, and an understanding of abstract ideas. At this point, people become capable of seeing multiple potential solutions to problems and think more scientifically about the world around them.

Socio-culturalism

During the 1980s, Russian psychologist Lev Vygotsky challenged many perceptions about learning and education with his theories of mind and society (Oldridge, 2010). Vygotsky believed that learning and development is both internal and external. He had similar views to Piaget about the internal cognitive nature of learning, but placed greater emphasis on external social factors. He believed that cognitive development and maturation extends from social activities and that interaction with adults plays a crucial role in fostering development. He proposed the idea of the zone of proximal development to explain this learning process, and others have built on the idea of scaffolding as means of supporting and driving cognitive development.

Learning through Social Interaction and Internalisation

Vygotsky conceptualized development as the transformation of socially shared activities into internalized processes (John-Steiner & Mahn, 1996). Principally he highlighted language use as the precursor of cognitive development, as it allows for external information to be internalized. Internalization is not simply the transferring of external information into internal thought, rather children build personal interpretations of the world based on individual experiences and interactions (Ertmer & Newby, 1993, p. 63). This is similar to Piaget's understanding of schema development but Vygotsky believed that social, cultural and language interactions mediated the processes of learning.

A key distinction between Vygotsky and Piaget is that Piaget believed that cognitive development precedes learning and socialisation, whereas Vygotsky believed learning and socialisation lead to development. Vygotsky (1978) would posit that learning awakens a variety of internal developmental processes that are able to operate only when the child is interacting with people in his environment and in cooperation with his peers. Vygotsky (1978) further expands on this by explaining that learning is not development; however, properly organized learning results in mental development and sets in motion a variety of developmental processes that would be impossible apart from learning.

Instead of focusing on individual development, as in behaviourist and cognitivist approaches, Vygotsky highlighted the importance that social experiences and supports have on cognitive develop. The sociocultural approach views the child as a social being that learns about their world through conversations and interactions with others. These interactions can be informal episodes or intentionally designed experiences. In both situations adults may demonstrate and convey to children their interpretations of objects, events and experiences. Social interactions that children have are greatly influenced by their wider cultural context. Interactions with other people are "the critical mechanism underlying development as it leads to a reorganization of the child's thought processes and abilities at a higher cognitive level" (Robb, 2010, pg.24).

Zone of Proximal Development and Scaffolding

An important concept related to information mediation is the zone of proximal development, commonly referred to as ZPD. In Vygotsky's words the zone of proximal development is "the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (Vygotsky, 1978, p. 86). Vygotsky introduced the idea that children can perform more challenging tasks when assisted by more advanced and competent individuals, and, through different support processes, children can learn to do more things on their own without assistance. Wood, Bruner,

& Ross (1976) expanded on Vygotsky's work and derived the term 'scaffolding' to explain assistance and guidance in the zone of proximal development. Scaffolding allows learners to become more competent with tasks on their own and progress their ZPD on to encompass more challenging tasks. Scaffolding is an active and reactionary process wherein the teacher or parent responds to the learner's actions and keeps them focused on a task, maintaining the child's interest and motivation, through managing the task, modelling solutions and providing support where needed. For scaffolding to be effective, parents must be sensitive to their child's abilities and needs and finely tune their own actions on an on-going basis (Robb, 2010, pg.23).

4.2 Chapter 4 Summary

To design educational applications and media it is important to understand how learning occurs and how to stimulate and support that process. Knowing the differences between learning theories and also how they may be embedded into software and technology design is a critical aspect of designing material that has an educational goal. Learning theories are distinct and may be conflicting at times. They analyse and describe learning and development in their own way. Different aspects of learning theories may be incorporated together and separate learning theories may be more appropriate and applicable in certain circumstances. These theories can play a major role in the types of outcomes a technology may enable because of what features and teaching methods the theories inspire. Knowing when, how and why to employ a learning theory and teaching methods into an app's design allows that project to be informed by proven methods and scientific evidence relating to that theory.

Chapter 5: Revisiting Ideation and Prototyping

Considering what researchers and reviewers have to say about applications and from personal experience of the app design process I believe that how an app idea is formed and how features and functions are derived are inherently related to how that app performs as an educational tool. My research into what types of apps are available and how they may be influenced by learning theory has changed the way I view how to design an 'educational' app.

In this section I expand upon the way my own ideation process has changed by utilising practice led methodology in the form of concept or idea prototyping. The following idea prototypes are a reflection of my personal advancement of knowledge (Candy, 2006) about the practice of app design . The app ideas are an expression of a more informed creative method and demonstrate potential ways developers could ideate apps by deriving features from theory. The idea prototypes presented focus on functional properties and show a framework for design, rather than a full-fledged working prototype with an interface, illustration and media. In future these apps may be taken through to working prototypes but the goal of this project was to revisit the ideation phase of app design rather than the full development process which is beyond the technical scope of this research.

The following section presents two idea prototypes: '*To the Moon and Back'*, a dialogic storybook app, and '*mARker*' an augmented reality tool. The features and functions of '*To the Moon and Back'* and '*mARker*' are detailed below and I explain why they are included in relation to the learning theories they are derived from. I also give a short critique of the ideas and explain ways the development process could extend them.

5.1 To the Moon and Back

While there are an extensive number of storybook applications available on the Appstore many of them contain the same features which have been proven to only slightly, or not at all, improve literacy learning opportunities. Socio-cultural theories and teaching methods such as scaffolding and the zone of proximal development (Vygotsky, 1978) would suggest that much of the benefit of storybook reading comes from dialogic reading with supportive teachers and parents. In dialogic reading the adult guides the reading activity and encourages the child to engage with the text through questioning and re-framing elements in the story. Instead of just reading the story the adult often takes the role of an audience to the child and shares in the reading activity.

A book or ebook can be used to stimulate dialogic reading and facilitate teachable, interactive and personal moments between a parent or teacher and a reader. Interactive features are usually only directed at engaging a child but can also be useful in providing a context for adults to interact with their children (Robb & Lauricella, 2014). 'To the Moon and Back' has been designed to extend the affordances of simple ebooks and combine features of other applications into one cohesive format in order to primarily support dialogic, joint book reading through it's supportive and informative features. It does this through its base narrative, situational support advice, a creative reconstruction mode and customisable levels of content.

'To the Moon and Back' features an original story which acts as a base for its supportive features. This story has been designed with the intention to engage both the child and parent/caregiver through relatable content. The story mirrors a typical parental relationship, is set in a familiar environment and revolves around a common act, all of which are chosen so targeted users would have a high chance to relate to content. The full base narrative is about a father and daughter in a household environment around bedtime. The father is trying to get the daughter to go to bed, but the daughter insists on him staying up and playing. The story is propelled through the daughter's curiosity and imagination and the father's encouragement and support. There are subtle elements in the story that cater to parent readers, such as the underlying intention of the father character to get his daughter to sleep and humor revolving around the idea of the impatience and egocentrism of children. The base story also rhymes, this was a design choice based on the idea of adding in rhythm and readability, which sets a pace for the story but also allows for phonemic associations to be built between words.

The base story is as follows:

"To the moon and back.

How far away is the moon?
If we left now, would we be there soon?

I'm not sure little one. It would take a long long time but does sound fun.

What if we take a rocket ship?
Would it still be, a long long trip?

Not if we make one with a hyperdrive! Let's start building and take a ride

What do we need to build the rocket?
Shall I get glue from the closet?

We need glue, and boxes and maybe that pan. Pass me them all, if you can.

Don't forget the hyper drive!
If this takes any longer I will be six not five!

Hop on in I think we're done, let's go to space and have some fun!

Are we going to be there soon?
I really want to see the moon!

Hold on tight, we've just begun, We're taking off in 5, 4, 3, 2... 1!

Is it still that far away?
We won't even have time to play!

Don't be silly, of course there is! We'll be there within a whizz

How many stars are there in the sky?
I'm getting sleepy, I don't know why

We're almost there, not much longer to wait.
Count the stars to keep awake

1… 2… 3... 4…..
My eyes won't stay open, any more
5, 6, 7, 8…., 9……..,10.....
Can you do the rest of them?

I'll do my best little one,
Counting without you is no fun.

But rest your head,
Because it's time for bed.

The stars will be there when the sky is black,
I'll always love you, to the moon and back."

This application will support the dialogic reading process with a detailed 'Parents and Adults' section which will display information directed at an older supportive reader. In addition to explaining how the application functions, this section will feature information on joint book book reading, dialogic enquiry and other methods that support the process of reading and scaffolding. Information in this section looks to support, educate and guide parents on the

positive impacts they can have on their child's literacy development through scaffolding techniques. Instead of being one text page accessible from the home menu, this page will be accessible anytime during operation through a 'parents' button. This allows for contextual information to be shown if the base story is being read. For instance, if the support button is pressed on Page 3 (which depicts the father and daughter building a rocketship), the support information shown would say: "Reading and stories don't just have to stay in books, acting out events and characters from stories can help children remember and comprehend texts. Encourage your child to retell and relate elements from stories to real world activities. You could try and build your own rocketship from your closet and talk about the different parts you would use to make it."

'*To the Moon and Back'* will also allow users to customise content to better suit their own personal context. Another application that does this well is the I-Imagine app, which allows users will to change the appearances of characters in the story. In this application, users will be able to configure appearance of characters from some preset options. This feature is present so that users can adjust characters to model themselves, others or however they see fit. This element is added to help joint book reading so that users have a choice to allow for more relevant/relatable characters in the story. Allowing a child to take an active approach in expressing interpretations transform texts to meet their needs and interests, making the reading experience more individualized, interactive and engaging.

Users will also have the option to alter and save different versions of the narrative's text. This allows parents and children to alter the story to cater to their own environment, imaginations and interpretations. This allows more 'learned others' to further adjust the content to suit the reader. It provides an opportunity to support key dialogic reading moments by letting the adult and child interpret and write a story together. This activity would provide many opportunities for the adult reader to ask questions about the story and characters, and directly engages both users in the creation process. This feature could then be used independently later on in a child's literacy development to practice skills of writing and storytelling. This reconstruction feature adds in lasting value for the application because of the multiple stories that users may create. It is not as open as regular story creation apps, but frames and guides story creation through its illustration and parental instruction.

A key idea of this application is to support the process of scaffolding and the zone of proximal development by having scalable content. Instead of incremental progression through levels of content, this app will have one base story comprised of a set of pages where content on each page can be adjusted through different levels by users at anytime. This allows users or more experienced others to adjust content to suit the learner's ability during reading and also cater to separate readers across multiple sessions. The content that is displayed on each level

of each page will be designed around different levels of literacy development. In this app there will be five ‘levels’, or layers, for every page of the story. These levels have been designed to mirror traditional literacy development stages. The stages are as follows:

Level 1. No words or text - just the illustration
Level 2. Alphabetic principles - Only displaying letters and some relevant words than begin with each letter. This level functions like an alphabet book. Letters and words are relevant to visual elements in frame.
Level 3. Phonics - Phonetic sounds that are relevant to visual elements in frame
Level 4. Short sentences - Simple text using short sentences
Level 5. Complex sentences - Full story with grammar, rhyme

The following diagrams illustrate how the separate levels are structured in relation to pages of the story.

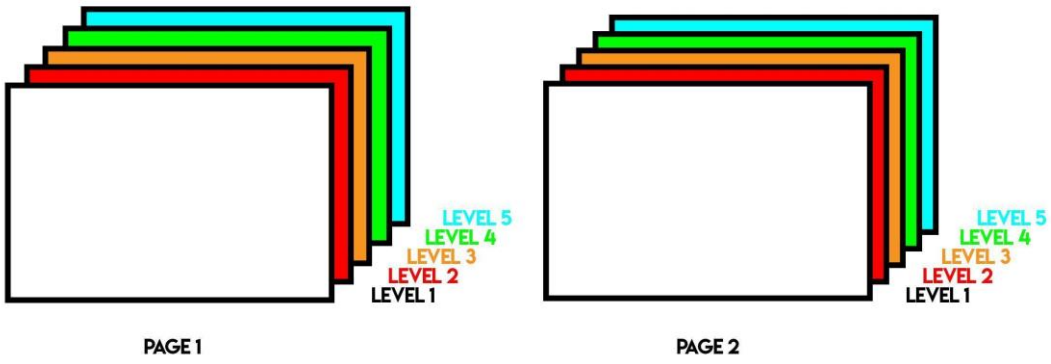

Figure 1 - *To the Moon and Back* Pages and Levels

There will be 10 pages in the story. Each story page features an illustration and text based upon what level the user is at. Users will transition between pages to progress in the story and transition between levels to match literacy level.

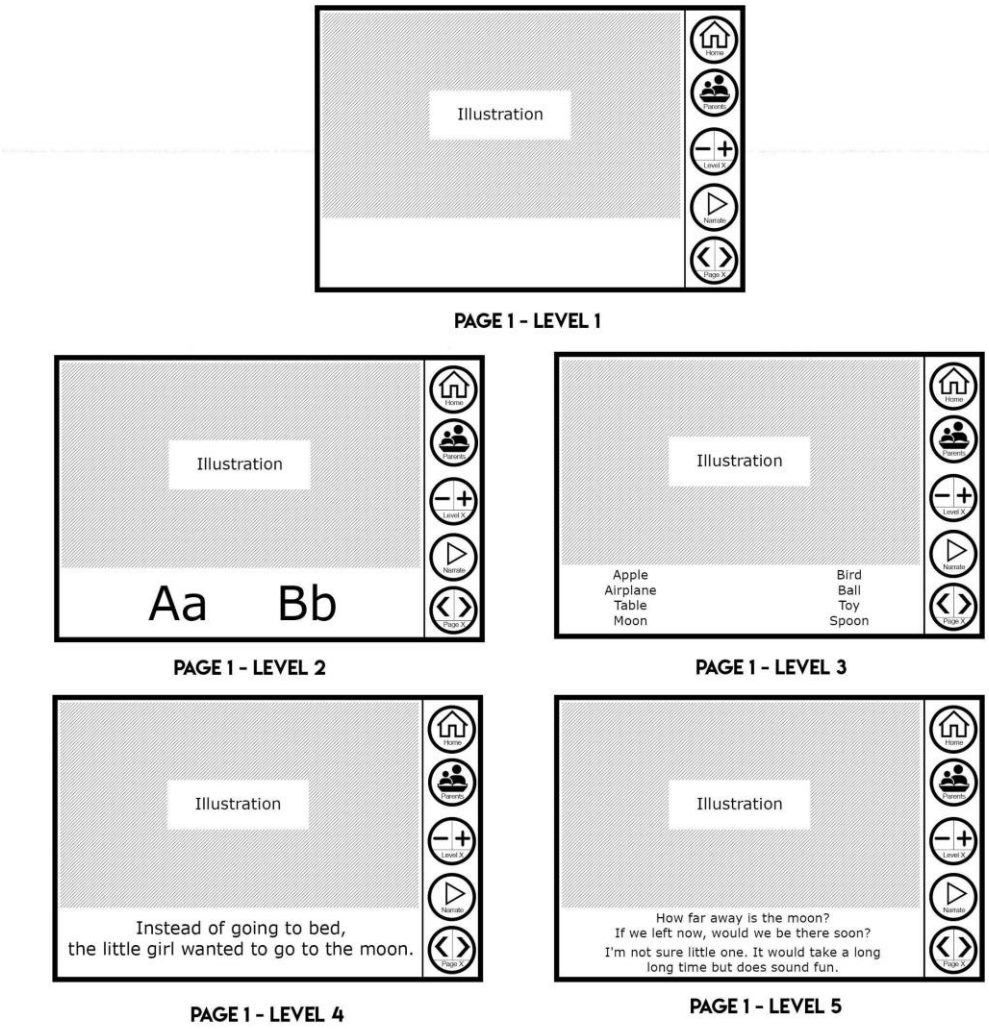

Figure 2 - *To the Moon and Back* Levels of Page 1 Example

Above is an example of how content will vary for page 1. On the right hand side of the window users may adjust through levels and pages using buttons. They can also access the parents/support button and narration options, as well as return to the home screen.

Figure 3 - *To the Moon and Back* Text changes through levels

The figure above demonstrates how the different levels may affect what text is displayed onscreen. Note level 1 features only the illustration so no text is displayed

An explanation of these levels and how to progress through them with scaffolding techniques will be presented in the aforementioned 'Parents & Adults' section. The levels are present to match different levels of children's literacy skill but also function as a demonstration of what kind of elements an adult could focus on during other dialogic book reading activity. For instance, in another book or application an adult could adapt this level system with a child that is just starting to learn alphabetical principles and focus on encouraging the child to identify visual elements in frame that begin with a certain letter, like in level 2 of To The Moon And Back.

To The Moon And Back is designed to support dialogic reading, scaffolding and the zone of proximal development. It combines the familiar format of the storybook with guiding information for adults, customisable text elements and the ability to scaffold content specifically to a reader. It forgoes some of the usual multimedia additions that ebooks regularly employ to focus on supporting a joint learning process. While the high focus on joint media engagement lines up well with best practices for early literacy development the execution of this app's media would be an integral aspect of whether or not users would be engaged with the application. The ability to change characters and text allows content to be made more relevant and relatable to many different users, but how the base story and accompanying illustration is received will still play a role in initial engagement. Additionally, the varied level system may be altered to further reinforce the role parents may take. Removing the five levels and having the option to transition between no text, story text and then users' own generated text would consolidate the app's features and could make the interface less complicated. Targeting different literacy skills could be moved into the parental help section, so that the adult remains the driver for different tasks, which could help with adult engagement. The removal of strict levels would mean this format could easily be extended to other stories. Overall the app has potential to aid literacy development by targeting a joint reading experience, and the specifics of media, content and levels could be worked out through a development process.

5.2 mARker

'mARker' is a tool that seeks to spark shared moments of engagement between adults and children and immerse them in language-expression experiences. The features of the app are based upon Piaget's (1952) notions of schema, accommodation and assimilation. It also takes cues from Constructivist and Socio-cultural theories about active discovery and communities of knowledge and is designed specifically for multiple users and early educational environments (Vygotsky, 1978). *'mARker'*, is a creation/augmented interaction app that utilises augmented reality technology in order to engage users with words, media and stories in localised physical and digital spaces. The app focuses on engaging children in a socially

creative process that looks to develop new literacy skills, as well as engage children in creative activities outside the tablet.

Augmented reality allows a variety content to be displayed on a digital screen if a marker is identified with the device's camera. A marker is a physical item with a distinct visual appearance. QR codes are a fairly well known application of augmented reality however the square, black and white pattern is not the only marker that can be used to load content. The *mARker* app will enable learners and teachers to create their own markers as a separate physical activity, and then load them into them app via the camera. Text, images or video will then be able to be 'linked' to the marker. When the app is in a 'seeking' mode, the camera can recognise the marker and then display the linked media. When this is done the marker is linked with a learner's name, which simply contains all of the markers and media content the user has created within the app. The attached content could be loaded from the devices existing gallery, or users could create new content to link to the marker. This content would be text, photo, audio or video, all of which the iPad is capable of recording by itself.

This application has been designed to encourage outdoor activity and exploration. It prompts children to take an active role in expressing their knowledge and creativity across a physical and digital space. This focus stems from both Cognitivist and Sociocultural theories which are outlined in Chapter 4. This app embodies and adapts those ideas by allowing users to place markers around their physical environment and link media to it. For instance, in an early childhood center there might be a tree outside which could be linked with a video depicting seasonal change. Or there may be an alphabet wall and a user could link a letter with a picture corresponding to that letter. '*mARker*' enables letters, words and media to be linked together by specific users. This is done to mimic the theorised internal processes of assimilation. The 'seeking' mode allows users to look at links and media other people have created which could prompt accommodation of new schema through internal comparison of user's own understandings or by sparking discussion between users about what they have chosen to do. The app facilitates opportunities for social interaction between children by involving them in a creative and expressive task which is meant to be shared with others. The communal aspect of this activity is designed to allow for multiple perspectives, opinions and approaches to be displayed and to facilitate discussion between users about what markers they've placed and why they have linked certain text or media to things.

The following diagrams depict the user interface of *mARker* and demonstrate how the different features would be organized.

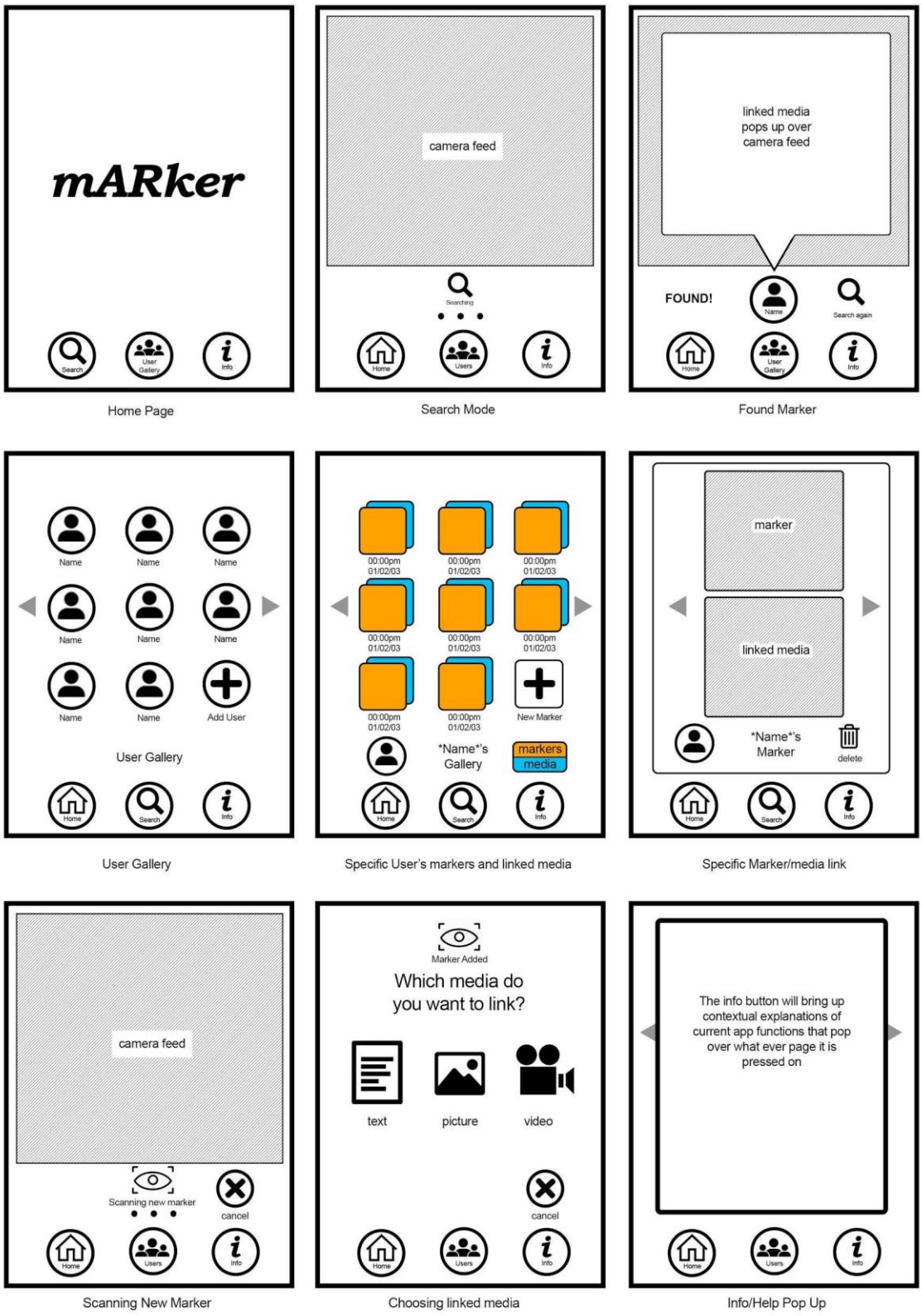

Figure 4 - *mARker* interface and features

This app could directly reinforce key areas of New Zealand's early childhood curriculum Te Whariki (2016) by empowering the child through a creative process and supporting relationships between people, things and places. It provides new opportunities for children to develop skills such as communication, exploration and reflection, all framed in the task of expressing knowledge and literacy skills. This app can be used in a lot of different ways and is not focused on a certain skill in contrast to many existing literacy apps. One of the chief concerns about children using apps and tablets is over consumption of media, too much screen time and app use detracting from physical, social and creative activities away from technology. This app could do a good job of emphasizing development of new media skills and literacy development whilst encouraging social and creative activities outside of the tablet itself. However, all of these pros hinge upon whether or not the app is able to be used effectively. Using augmented reality could well be too complicated for early childhood settings and the main goal of the development process would be to create an accessible, user-friendly interface. *mARke*r has potential to be developed into a working prototype but the program's interface is the biggest factor that would determine whether or not it could engage users in literacy activities.

5.3 Chapter 5 Summary

The ideation and design phase of an app development project reflects the designer's priorities and intent. How elements are chosen and why they are included in these initial steps is indicative of later educational value. The two idea prototypes I have presented are concepts which demonstrate a more informed approach to the design process. The features and functions of the applications intend to facilitate learning and are derived from theories of learning*. To the Moon and Back* is a storybook app which focuses on joint media engagement and supporting positive parent-child interactions which is inspired by socio-cultural theories and teaching methods . Whereas *mARker* is a creation/ augmented-interaction hybrid app that seeks to use augmented reality as a means to facilitate digital and non-digital interactions between users which is inspired by cognitivist understandings of the mind. These are just concepts and would need to be developed into working prototypes using rapid development cycles to ensure the apps are user friendly and engaging. However, by basing the initial design, features and functions upon learning theories and teaching methods they already show more promise of educational value than my own previous ideas and some existing applications. A full development and testing cycle would allow hard data to prove or disprove this hypothesis, but those steps were beyond the scope of this current work and time limitation of this thesis.

Chapter 6 - Conclusion

The goal of this research was to investigate how tablet based applications could be designed to better facilitate the development of early reading skills for children. I approached this goal from a designer's perspective as a means of reflecting upon my own practice as well as to stress the wider disconnect between the types of products app designers are publishing and the core ideas and theories present in educational literature.

I chose to first investigate what type of applications were currently being developed and what educational researchers had to say about them. This was done to situate my own design work and to identify what common criticisms could be drawn about existing apps. Through this inquiry into other works and criticisms I discovered a gap in my own understandings about the fundamental processes of learning and development. To extend my knowledge in this area and also to outline key areas for other designers, I reviewed the three core understandings of learning - Behaviourism, Cognitivism and Social Constructivism. Exploring these theoretical positions allowed me to draw parallels between app design features and learning theories, such as the link between intermittent rewards, animated encouragement and Behaviourism. This was reinforced by multiple views from research that detailed how an app's features and functions were reflective of how that designer views users should learn or play. The key finding that I took from this inquiry was how a base learning theory can inform and influence the ideation of an app to lead to solutions with more potential to aid the learning process.

Knowledge of these different theoretical understandings of learning can be useful to designers as those theories may be used as basis for the design process, as well as a way to iteratively reflect upon the effectiveness and appropriateness of app features during the development process. To demonstrate how the design approach can be informed and centered around a theory of learning I utilised aspects of practice based methodology to ideate and prototype two separate apps - *To the Moon and Back* and *mARker. To the Moon and Back* is a storybook app which draws from socio-cultural theories by utilising the iPad as a platform for joint media engagement to support positive parent-child interactions. *mARker* is a creation/ augmented-interaction hybrid app that seeks to use augmented reality as a means to facilitate digital and non-digital interactions between users which is inspired by cognitivist understandings of the mind. Design decisions for both of these applications were made with express intent to reinforce actions and behaviours that related to the apps respective core base theories. For instance, the story in *To the Moon and Back* is not simply there for entertainment but was created to model some of the supportive parent-child interactions that the application seeks to foster.

The idea prototypes presented show a development in my personal approach to educational app design. The way in which these apps were conceived and the ways their

features, content, and interactions were developed was centered around sociocultural and cognitivist theories. This approach may serve as a demonstration to other designers about how they can go about the design process to create outcomes which more closely align with established models and theories of learning. In this sense the idea prototypes do achieve my original goal of investigating *how* tablet based applications could be designed to better support learning but without taking the ideas I conceived through to working prototypes, testing them with children and evaluating those results they remain as mere indications of better design. This is a major limitation of this research and furthering the design process would allow for investigation into how other aspects of a design method may affect an application's educational value. Fully developing apps would also allow an investigation of interaction design and visual design in relation to engagement, learning and theory. However this project was limited in scope to focus on my response to research as a designer, and how I utilised the research process to inform my design practice.

When investigating literacy development I found there to be a significant number of factors that contribute to whether or not an app could or could not help learning in this area. However it was not possible to address to all of them within the time constraints of this Master's project. There are various measures which could be used to determine progress and effectiveness in literacy development, such as vocabulary development and story comprehension, which I have only briefly touched on. I did not address the different understandings of what literacy is, the difference between phonics and whole language, or discuss digital literacy. Further inquiry into these areas would complement the work I did do on learning theory and build towards a more comprehensive design approach. This area could be investigated more deeply in the future and the design process could be applied to develop applications that target specific educational goals that are under-represented in the market. For instance, there are numerous applications that target basic skills such as alphabet knowledge and phonemic awareness but not many that target higher skills such as comprehension or sentence structure. Further research into literacy development apps should acknowledge this area more deeply and incorporate that information into the app design process.

In conclusion, just as teachers, schools and parents have a responsibility to assess how technology fits into the lives of children (Guernesy, 2012), app developers too, have a responsibility to ideate, design and develop applications that are beneficial and helpful to the young audiences they target. This thesis identifies a disconnect in the design process between learning theory and design outcomes. A deeper understanding of how children learn, and how to stimulate and support that process is required to design applications that have educational goals, if they are to meet these learning outcomes. This gap may be addressed early in the design process by deriving content, features and interactions from learning theory as demonstrated by the prototypes presented in this work.

References

Age of Learning Inc. (2017). *ABCMouse.com* (5.9.1) [Mobile application software]. Retrieved from https://itunes.apple.com/us/app/abcmouse-com/id586328581?mt=8&ign-mpt=uo%3D4

American Academy of Pediatrics. (2016). *American Academy of Pediatrics Announces New Recommendations for Children's Media Use*. Retrieved from https://www.aap.org/en-us/about-the-aap/aap-press-room/pages/american-academy-of-pediatrics-announces-new-recommendations-for-childrens-media-use.aspx

Apple. (2015). *Appstore Review Guidelines*. Retrieved from https://developer.apple.com/app-store/review/guidelines/ on 16/10/2016

Ard. L.M. and Beverly. B. (2004). Preschool word learning during joint book reading: Effect of adult questions. *Communication Disorders Quarterly, 26(1), 17-28.*

Beschorner, B., & Hutchison, A. (2013). iPads as a literacy teaching tool in early childhood. *Online Submission*, *1*(1), 16-24.

Billington, C. (2016). How digital technology can support early language and literacy outcomes in early years settings: A review of the literature. London: *National Literacy Trust.*

Bizzibrains Pty Ltd. (2016). *I-Imagine* (1.07) [Mobile application software]. Retrieved from https://itunes.apple.com/us/app/i-imagine/id771569926?mt=8&ign-mpt=uo%3D4

Blackwell, C. K., Lauricella, A. R., Wartella, E., Robb, M., & Schomburg, R. (2013). Adoption and use of technology in early education: The interplay of extrinsic barriers and teacher attitudes. *Computers & Education, 69, 310-319.*

Bransford, J. D., Brown, A. L., & Cocking, R. R. (1999). How people learn: Brain, mind, experience, and school. *National Academy Press.*

Buckleitner, W. (2014). What Would Maria Montessori Say About the iPad? Theoretical Frameworks for Children's Interactive Media. *Technology and Digital Media in the Early Years: Tools for Teaching and Learning, 54.*

Candy, L. (2006). Practice based research: A guide. *CCS Report*, *1*, 1-19.

Chau, C. L. (2014). *Positive Technological Development for Young Children in the Context of Children's Mobile Apps (Doctoral dissertation, Tufts University)*. Retrieved from https://ase.tufts.edu/DevTech/resources/Theses/CChau_2014.pdf

Chera, P., & Wood, C. (2003). Animated multimedia 'talking books' can promote phonological awareness in children beginning to read. *Learning and Instruction, 13(1), 33-52.*

Common Sense Media. (2013). *Zero to eight: Children's media use in America*. Retrieved from https://www.commonsensemedia.org/file/zero-to-eight-2013pdf-0/download

De Jong, M. T., & Bus, A. G. (2004). The efficacy of electronic books in fostering kindergarten children's emergent story understanding. *Reading Research Quarterly, 39(4), 378-393.*

Dezuanni, M., Dooley, K., Gattenhof, S., & Knight, L. (2015). *iPads in the early years: Developing literacy and creativity.* Routledge.

Doty, D. E., Popplewell, S. R., & Byers, G. O. (2001). Interactive CD-ROM storybooks and young readers' reading comprehension. *Journal of Research on Computing in Education, 33(4), 374-384.*

Egeblad, J. (2017). *Strip Designer* (1.18.21) [Mobile application software]. Retrieved from https://itunes.apple.com/us/app/strip-designer/id314780738?mt=8&ign-mpt=uo%3D4

Ertmer, P. A., & Newby, T. J. (2013). Behaviorism, cognitivism, constructivism: Comparing critical features from an instructional design perspective. *Performance Improvement Quarterly, 26(2),* 43-71.

Falloon, G. (2013). Young students using iPads: App design and content influences on their learning pathways. *Computers & Education, 68*, 505-521.

Flewitt, R., Kucirkova, N., & Messer, D. (2014). Touching the virtual, touching the real: iPads and enabling literacy for students experiencing disability. *Australian Journal of Language & Literacy, 37(2)*, 107-116.

Fred Rogers Center. (2012). *Alien Assignment* (1.0) [Mobile application software]. Retrieved from https://itunes.apple.com/us/app/alien-assignment/id531359578?mt=8

Gauvain, M. (2001). *The social context of cognitive development*. Guilford Press.

Gong, Z., & Levy, B. A. (2009). Four year old children's acquisition of print knowledge during electronic storybook reading. *Reading and Writing, 22(8),* 889-905.

Guernsey, L., Levine, M., Chiong, C., & Severns, M. (2012). Pioneering literacy in the digital wild west: Empowering parents and educators. *New York: New America Foundation & Joan Ganz Cooney Center.*

Gutnick, A. L., Robb, M., Takeuchi, L., & Kotler, J. (2011). Always connected: The new digital media habits of young children. In *New York: The Joan Ganz Cooney Center at Sesame Workshop*.

Hirsh-Pasek, K., Zosh, J. M., Golinkoff, R. M., Gray, J. H., Robb, M. B., & Kaufman, J. (2015). Putting Education in "Educational" Apps Lessons From the Science of Learning. *Psychological Science in the Public Interest, 16(1), 3-34.*

Hisrich, K., & Blanchard, J. (2009). Digital media and emergent literacy. *Computers in the Schools, 26(4)*, 240-255.

Hutchison, A., Beschorner, B., & Schmidt- Crawford, D. (2012). Exploring the use of the iPad for literacy learning. *The Reading Teacher, 66(1), 15-23.*

Ihmeideh, F. M. (2014). The effect of electronic books on enhancing emergent literacy skills of pre-school children. Computers & Education, 79, 40-48.

Allen Interactions (2017) *Iterative eLearning Development with SAM*. Retrieved from http://www.alleninteractions.com/sam-process

John-Steiner, V., & Mahn, H. (1996). Sociocultural approaches to learning and development: A Vygotskian framework. *Educational psychologist, 31(3-4)*, 191-206.

Kindoma Inc. (2017). *Storytime: Read with your Kids over Video Chat* (4.7.0) [Mobile application software]. Retrieved from https://itunes.apple.com/us/app/storytime-read-with-your-kids-over-video-chat/id621742145?mt=8&ign-mpt=uo%3D4

Kucirkova, N. (2014). iPads in early education: separating assumptions and evidence. *Frontiers in Psychology*, 5.

Korat, O., & Shamir, A. (2007). Electronic books versus adult readers: Effects on children's emergent literacy as a function of social class. *Journal of Computer Assisted Learning, 23(3),* 248-259.

Labbo, L. D., & Kuhn, M. R. (2000). Weaving chains of affect and cognition: A young child's understanding of CD-ROM talking books. *Journal of Literacy Research, 32(2),* 187-210.

Larson, L. C. (2010). Digital readers: The next chapter in e- book reading and response. *The Reading Teacher, 64(1)*, 15-22.

Leeflang, J. (2015). *Apple App Store vs. Google Play Store: 3 Major ASO Differences*. Retrieved from http://www.applift.com/en/blog/ios-app-store-google-play

Lynch, J., & Redpath, T. (2014). 'Smart' technologies in early years literacy education: A meta-narrative of paradigmatic tensions in iPad use in an Australian preparatory classroom. *Journal of Early Childhood Literacy, 14(2)*, 147-174.

Maynard, S., & McKnight, C. (2001). Children's comprehension of electronic books: On empirical study. *New Review of Children's Literature & Lib, 7(1)*, 29-53.

McLeod, S. A. (2010). *Preoperational Stage.* Retrieved from http://www.simplypsychology.org/preoperational.html

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

McQuiggan, S., McQuiggan, J., Sabourin, J., & Kosturko, L. (2015). *Mobile Learning: A Handbook for Developers, Educators, and Learners.* John Wiley & Sons.

Moody, A. K. (2010). Using electronic books in the classroom to enhance emergent literacy skills in young children. *Journal of Literacy and Technology, 11(4)*, 22-52.

Naranjo-Bock, C., & Ito, J. (2017, June). Playing together: The importance of joint engagement in the design of technology for children. In Proceedings of the 2017 Conference on Interaction Design and Children (pp. 749-752). ACM.

Neumann, M. M. (2014). An examination of touch screen tablets and emergent literacy in Australian pre-school children*. Australian Journal of Education, 58(2)*, 109-122.

O'Hare, E. (2014). Mobile apps for children. Criteria and categorization. *Research report, the Netherlands*.

Oldridge, L. A. (2010). Digital foundations: a study of perceptions and practices surrounding the use of ICT in ECE centres: this thesis is submitted in part fulfilment of the requirements for the Doctor of Education, Massey University.

Originator Inc. (2017). *Endless Reader* (2.9) [Mobile application software]. Retrieved from https://itunes.apple.com/us/app/endless-reader/id722910739?mt=8&ign-mpt=uo%3D4

Paciga, K. A. (2014). Their teacher can't be an app: Preschoolers' listening comprehension of digital storybooks. *Journal of Early Childhood Literacy*, 1468798414552510.

Pavlov, I.P. (1927). Conditioned reflexes. London: Oxford University Press.

Peirce, N. (2013). Digital game-based learning for early childhood. *A state of the art report. Dublin, Ireland: Learnovate Centre*.

Piaget, J., & Cook, M. (1952). *The origins of intelligence in children* (Vol. 8, No. 5, p. 18). New York: International Universities Press.

Piaget, J. (1967). On the development of memory and identity.

Radich, J. (2013). Technology and interactive media as tools in early childhood programs serving children from birth through age 8*. Every Child, 19(4),* 18.

Ricci, C. M., & Beal, C. R. (2002). The effect of interactive media on children's story memory. *Journal of Educational Psychology, 94(1)*, 138.

Reeve, C. (2012)*. Behaviourism and Games. Play with learning*. Retrieved from http://playwithlearning.com/2012/01/06/behaviourism-and-games/

Reeves, B., & Nass, C. (1996). *How people treat computers, television, and new media like real people and places* (pp. 3-18). CSLI Publications and Cambridge university press.

Rimmer, T. (2016). *An Introduction to SAM for Instructional Designers.* Retrieved from https://community.articulate.com/articles/an-introduction-to-sam-for-instructional-designers

Robb, M. B. (2010). New ways of reading: The impact of an interactive book on young children's story comprehension and parent-child dialogic reading behaviors.

Robb, M., & Lauricella, A. (2014). Connecting child development and technology: what we know and what it means. *Technology and Digital Media in the Early Years: Tools for Teaching and Learning,* 70-85.

Selwyn, N. (2011). *Education and technology: Key issues and debates*. Bloomsbury Publishing.

Shuler, C., Levine, Z., & Ree, J. (2012). *iLearn II An analysis of the education category of Apple's app store*. Retrieved from http://www.joanganzcooneycenter.org/wp-content/uploads/2012/01/ilearnii.pdf

Simmons, N. (2006). Mathematics in early childhood: Exploring the issue. Retrieved from https://cdn.auckland.ac.nz/assets/education/about/research/docs/FOED%20Papers/Issue%2017/ACE_Paper_8_Issue_17.doc

Skinner, B. F. (1936). Conditioning and extinction and their relation to drive. *The Journal of General Psychology, 14(2),* 296-317.

Spencer, K.M., Coutts, T., Fagan, T., & King, A. (2013). Connections, Diversity, Coherence: Three Vignettes Exploring Learning with iPads in Primary Schools. *Computers in New Zealand Schools: Learning, teaching, technology, 25(1–3)*, 38–55

Polished Play LLC. (2017). *Puppet Pals HD* (1.9.2) [Mobile application software]. Retrieved from https://itunes.apple.com/us/app/puppet-pals-hd/id342076546?mt=8&ign-mpt=uo%3D4

Sandviks, HOP. (2017) *Hooked on Phonics - The #1 Learn to Read Program* (5.0.12) [Mobile application software]. Retrieved from https://itunes.apple.com/us/app/hooked-on-phonics-the-1-learn-to-read-program/id588868907?mt=8&ign-mpt=uo%3D4

Simon and Schuster Digital Sales Inc. (2012). *The Fantastic Flying Books of Mr. Morris Lessmore* [Mobile application software]. Retrieved from https://itunes.apple.com/us/book/the-fantastic-flying-books-of-mr-morris-lessmore/id499131668?mt=11&ign-mpt=uo%3D4

Spinlight Studio. (2017) *AlphaTots Alphabet* (2.75) [Mobile application software]. Retrieved from https://itunes.apple.com/us/app/alphatots-alphabet/id436142340?mt=8&ign-mpt=uo%3D4

The Open University. (2015). *Our Story for iPad* (1.31) [Mobile application software]. Retrieved from https://itunes.apple.com/us/app/our-story-for-ipad/id681769838?mt=8&ign-mpt=uo%3D4

Thorndike, E. L. (1932). The fundamentals of learning.

Toca Boca AB. (2017) *Toca Kitchen* (1.1.4) [Mobile application software]. Retrieved from https://itunes.apple.com/us/app/toca-kitchen/id476553281?mt=8&ign-mpt=uo%3D4

Trushell, J., Burrell, C., & Maitland, A. (2001). Year 5 pupils reading an "Interactive Storybook" on CD- ROM: losing the plot?. British journal of educational technology, 32(4), 389-401.

Vaala, S., Ly, A., & Levine, M. H. (2015). Getting a Read on the App Stores: A Market Scan and Analysis of Children's Literacy Apps. Full Report. In *Joan Ganz Cooney Center at Sesame Workshop*. Joan Ganz Cooney Center at Sesame Workshop. 1900 Broadway, New York, NY 10023. Retrieved from http://www.joanganzcooneycenter.org/wp-content/uploads/2015/12/jgcc_gettingaread.pdf

Verenikina, I., & Kervin, L. (2011). iPads, digital play and pre-schoolers. *He Kupu, 2(5)*, 4-19.

Verhallen, M. J., & Bus, A. G. (2010). Low-income immigrant pupils learning vocabulary through digital picture storybooks. *Journal of Educational Psychology, 102(1*), 54.

Vygotsky, L.S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge: MA: Harvard University Press.

Vygotsky, L.S. (1986). *Thought and language*. Cambridge, MA: MIT Press (original work published in 1934).

Vygotsky, L.S. (1987). *Thinking and speech*. (N. Minick. Trans.). New York: Plenum Press.

Wartella, E., Rideout, V., Lauricella, A. R., & Connell, S. (2013). *Parenting in the age of digital technology.* Report for the Center on Media and Human Development School of Communication Northwestern University.

Zucker, T. A., Moody, A. K., & McKenna, M. C. (2009). The effects of electronic books on pre-kindergarten-to-grade 5 students' literacy and language outcomes: A research synthesis. *Journal of Educational Computing Research, 40(1)*, 47-87.