Reading Between the Lines

An intervention concerning Reading Comprehension, Students with High-Functioning Autism Spectrum Disorder, and the design of educational software for Mobile Technologies.

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STATEMENT OF AUTHENTICITY AND ACCESS

I certify that this dissertation contains no material that has been accepted for the award of any other degree or diploma in any institute, college or university. In addition, to the best of my knowledge and belief, it contains no material previously published or written by another person, except where due reference is made in the text of the dissertation.

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STATEMENT OF ETHICAL CONDUCT

The research associated with this thesis abides by the international and Australian codes on human and animal experimentation, the guidelines of the Human Research Ethics Committee (Tasmania), the guidelines by the Australian Government's Office of the Gene Technology Regulator and the rulings of the Safety, Ethics and Institutional Biosafety Committees of the University. (See also Appendix A and Appendix B for approval of the project and subsequent amendments.)

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Tho' much is taken, much abides; and tho'

We are not now that strength which in old days

Moved earth and heaven, that which we are, we are;

One equal temper of heroic hearts,

Made weak by time and fate, but strong in will

To strive, to seek, to find, and not to yield. (Tennyson, 1842)

ABSTRACT

The present study explored language, communication, and reading comprehension deficits in students with High-Functioning Autism Spectrum Disorder (HFASD) and research in educational software applications (Apps) and mobile technologies. Many students with HFASD demonstrate difficulties in the acquisition of critical literacy skills such as reading comprehension, which research associates with the core deficits of the disorder. These core deficits include social communication, social interaction, and restricted or repetitive behaviours and interests. One of the ways these core deficits impact on students with HFASD is in face-to-face interactions and communicating with others. Mobile technologies and educational App software may be one way to support the development of reading comprehension of students with HFASD without the communication difficulties often experienced with face-to-face teaching and learning. Research concerning students with HFASD and the application of mobile technologies is emergent and as such limited. More notable, is a lack of research that could determine if educational software can develop the skills that underpin reading comprehension. As a result, the present study focussed on the design and development of an App to evaluate its effectiveness with this cohort of students. The three main research questions examined in this thesis are: (1) Can App software be designed to support measurable gains in reading comprehension for students with HFASD? (2) What are the key criteria and design features to consider when creating educational software for mobile technologies? (3) Considering the heterogeneous nature of students with HFASD, what attributes of characteristics influence students' results after using the software?

The participants involved in this research were aged from seven to twelve years with an in independent diagnosis of HFASD. A pilot study was initially conducted with two participants with HFASD to define and develop the treatment protocols for the main study. As a result, the main study utilised a single subject quasi-experimental case design involving nine participants, five boys and four girls. These students were assessed on measures including their vocabulary, comprehension, phonological awareness, and reading attitudes and behaviours.

The core findings of the present study describe improvements in reading comprehension for participants with specific deficits in vocabulary and comprehension. These findings are discussed in terms of the importance of understanding the heterogeneity of students with autism spectrum disorder and their learning needs. The findings review the theories that can be applied to understanding how the core deficits of this disorder contribute to problems in the acquisition of critical literacy skills, and how new educational technologies can be specifically developed and designed for this cohort of students to improve their learning. However, these findings have broader implications for educators and software developers in acknowledging the key pedagogical principles that underpin the success of educational technologies for all students in the classroom.

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Chapter 1 - Introduction

The aim of this thesis is to investigate the use of mobile technologies and the development of a software application (App), to ascertain if this mode of learning can support measureable gains in reading comprehension for students diagnosed with High-Functioning Autism Spectrum Disorder (HFASD). The results of this study contribute to deeper understandings across teaching, academic communities, and the broader community concerned with the learning benefits of Apps, mobile technologies, and individuals with autism. A description and overview of the nature and core deficits associated with autism and HFASD will establish a relevant context in which to place the present study.

1.1 Autism – A Definition

Autism Spectrum Disorder (ASD) is a lifelong developmental disability that affects the way in which an individual relates to their environment and how they interact with other people. The word 'spectrum' describes the broad range of difficulties that people with the disorder may experience, and the varying degrees of strength or impairment across developmental domains. Some individuals with the disorder live relatively typical lives, whilst others may require specialist support (Lord, Risi, Lambrecht, Cook Jr, Leventhal, DiLavore, Pickles, & Rutter, 2000). Diagnoses that fit within the autistic spectrum under the Diagnostic and Statistical Manual for Mental Disorders (DSM-V; American Psychological Association, 2013) include Pervasive Developmental Disorder Not Otherwise Specified (PDD-NOS), Asperger Syndrome, and autism spectrum disorder associated with Rett Syndrome and Childhood Disintegrative

Disorder. The core deficits characterised by the disorder are in social communication, social interaction and restricted or repetitive behaviours and interests (American Psychological Association, 2013). These deficits lead to confusion, misunderstanding, a lack of social competence and social isolation (Frith, 1991).

The term 'autistic' was first referenced independently by Kanner (1943) and Asperger (1944). This term was used to describe atypical behaviours in children observed as stereotyped and repetitive, a desire for sameness, the lack of imitative abilities, and atypical responses to sensory stimuli (Wing, 1991). Even though Kanner (1943) suggested that these behaviours had a biological basis present from birth, others such as Bettleheim (1967) theorised that these behaviours resulted from a psychiatric disability resulting from abnormal parent-child attachment. Subsequent research in neuropsychology has shown that differences in the perception and behaviour of individuals with ASD can be attributed to neurological differences, thus supporting Kanner's theory on the biological nature of the disorder (Frith, 1991; Yeung-Corchesne & Courchesne, 1997). Additionally, data shows that the relative risk of autism is 22 times greater in children who have a sibling diagnosed with autism (Lauritsen, Pedersen, & Mortensen, 2005), subsequently reinforcing a biological basis and genetic theory.

1.2 Variability in Functionality

Variations in areas of functionality have been documented in research between individuals diagnosed at the lower and higher ends of the spectrum (Klin, Volkmar, & Sparrow, 2000). For example, language development in autism is generally delayed and can be considerably impaired at the lower end of the autistic spectrum whereas, this is not always

demonstrated by those classified as higher functioning or HFASD (Howlin & Ashgarian, 1999; Wing, 1991). Variations have also been identified in Performance Intelligence Quota (PIQ) and Verbal Intelligence Quota (VIQ) across the spectrum (Klin et al., 2000; Vanvuchelen, Roeyers, & De Weerdt, 2011). Klin et al. (2000) describe higher levels of VIQ in comparison to PIQ in those diagnosed with HFASD, and conversely lower levels of VIQ to PIQ for individuals at the lower end of the autistic spectrum. These disparities are just one example of the variability that exists across the spectrum, and the heterogeneous nature of the disorder.

Core deficits within the social functioning domain in ASD are evidenced by difficulties in developing relationships with peers, lack of engagement with peers, problems with emotional recognition, and communication (Lord et al., 2000). Effective social interactions require the ability to process verbal information in the context of conversation, while at the same time processing many non-verbal cues such as facial expressions, hand gestures, posture, and eye gaze (Musarra & Ford, 2008). In order to develop social competence, an individual must be able to engage in reciprocal conversation and understand the skills involved in pragmatic communication. The variability in social and emotional responses across the spectrum range from social withdrawal and isolation to inappropriate approaches to others (Klin et al., 2000). For example, some individuals will show no interest in engaging with others socially, whilst others will express an interest in making friends and engage in detailed discussions concerning their topic of interest. Due to the social deficits associated with the disorder, these social attempts often lead to frustration as a result of frequent social failures (Klin et al., 2000; Lord et al., 2000).

1.3 Prevalence

Autism occurs in all racial, ethnic, and socioeconomic groups and is reported to be up to five times more prevalent in boys than in girls (Lord, Risi, DiLavore, Shulman, Thurm, & Pickles, 2006). In recent years, it has been purported that the number of individuals diagnosed with ASD has gradually increased, in particular those formally diagnosed at the higher end of the spectrum (HFASD) such as Asperger's Syndrome (AS) or Pervasive Developmental Disorder-Not Otherwise Specified (PDD-NOS) (Bryson & Smith, 1998; Wing & Potter, 2002). It had been estimated that the incidence of ASD in the United States is one child in every 110 children according to the Autism and Developmental Disabilities Monitoring (ADDM) network (Rice, 2009). Global estimates have previously reported similar statistics at 10 per 10 000 (Fombonne, 2003). More recently these estimates have changed, with the Centers for Disease Control in the United States estimating the prevalence of ASD to be 1 in 88 in 2008, and 1 in 68 children aged eight years in 2010 (Centers for Disease Control and Prevention, 2012, 2014). Many researchers have suggested for some time that the number of individuals with the disorder is increasing (Boyle, Boulet, Schieve, Cohen, Blumberg, Yeargin-Allsopp, Visser, & Kogan, 2011; Wing & Potter, 2002). For example, from 1997 to 2008 data indicates that the rate of autism had increased fourfold, from a prevalence of 0.19% in 1997 to 0.74% in 2008 (Boyle et al., 2011).

Conflicting theories concerning the reasons behind these increases in estimates have included changes in the diagnostic criteria of ASD (Mattila, Kielinen, Jussila, Linna, Bloigu, Ebeling, & Moilanen, 2007), and suggestions regarding an underestimation of the prevalence of autism in the past (Heussler, Polnay, Marder, Standen, Chin, & Butler, 2001). In Australia, although the prevalence of children with ASD has not yet been accurately estimated, available

data shows a consistency with the rates of diagnosis across other countries (Williams, MacDermott, Ridley, Glasson, & Wray, 2008). These estimates confirm the need for support services across all sectors of the community for individuals and families impacted by a diagnosis.

1.4 Implications of the Diagnosis in Education Contexts

As professionals are able to diagnose children with ASD from as young as two years of age, it should be expected that many of those with more severe symptoms of the disorder would be identified prior to school entry (Lord et al., 2006). It must be acknowledged though, that due to variability in autistic characteristics such as language and social behaviours, many children may go undiagnosed prior to beginning formal education, with parents at times incorrectly informed that the child will 'grow out' of the these initial problems (Hutton & Caron, 2005). One of the most extensive surveys conducted on age and diagnosis reported that in the United Kingdom, the average age for diagnosis was five and a half years (Howlin & Ashgarian, 1999). Furthermore, for those individuals who could be classified as HFASD, diagnoses have been reported to be much higher at around an average of 11 years of age. Early intervention programs have shown to improve educational outcomes for many children with ASD (Corsello, 2005; Harris & Handleman, 2000), therefore supporting the necessity of sustained and specific intervention programs. The majority of children with the disorder will attend school in mainstream educational settings (Yeargin-Allsopp, Rice, Karapurkar, Doernberg, Boyle, & Murphy, 2003). For students with ASD who are accessing mainstream education, a much greater range of academic skills is within reach. However, deficits in language and communicative

domains will often predicate barriers to learning specifically in the curriculum area of core literacy skills (Jordan, 2013).

1.5 Theoretical Perspectives related to Reading Comprehension

Research has continually highlighted areas of learning, such as reading comprehension, which seem to be problematic across the autism spectrum (Lindgren, Folstein, Tomblin, & Tager-Flusberg, 2009; Nation, Clarke, Wright, & Williams, 2006). To understand a text, readers must be able to integrate clauses and sentences to form semantic representations; although many students with ASD appear to display difficulties integrating syntactic and semantic information to create meaning (O'Connor & Klein, 2004). Theories which seek to explain comprehension problems in ASD have, for the most part, been founded on the language or information processing deficits associated with the disorder (Nation et al., 2006; Norbury & Nation, 2011). These theories have drawn parallels with the comprehension issues existing in typical populations, which are primarily concerned with the relationship between oral language deficits, intelligence, and poor comprehension.

An ability to read successfully and independently is an important lifelong skill which can have a positive impact on an individual's academic and vocational attainments (Carnine, Silbert, Kame'Nui, & Tarver, 2004). In order to become successful readers, children must develop specific literacy skills such as understanding letter sound relationships and building a 'bank' of recognized words, and efficiently organise, summarise and connect information (Perfetti, Landi, & Oakhill, 2005; Perfetti, Marron, & Foltz, 1996). Comprehension is the ultimate goal of reading which is described as a complex cognitive process. (Hay & Woolley, 2011; Perfetti et al.,

2005). Just as important though, are the strategies deployed to repair comprehension when a breakdown in understanding occurs (Cain & Oakhill, 2007; Oakhill & Yuill, 1996; Ricketts, 2011). The difficulties shown with reading comprehension in many diagnosed with autism are proposed to be attributed to three theoretical frameworks. These theories may provide some explanations for the problems demonstrated with making meaning from text (Gately, 2008).

Children with ASD often demonstrate an impaired or limited capacity in understanding others' states of mind, intentions and emotions, which researchers attribute to an inability to appropriately develop 'Theory of Mind' (ToM; Baron-Cohen, Leslie, & Frith, 1985; Frith, 1996). Furthermore, core social and language deficits associated with the disorder have been implicated in a child's capacity to acquire ToM (Frith, 1989; Meltzoff, 1999). Difficulty understanding inference and intentions as part of everyday conversations may well impair comprehension and understanding, particularly in face-to-face interactions (Ricketts, Jones, Happé, & Charman, 2013). It would be reasonable to extend this theory to cover understanding inferences within text, compounded by attempts to remediate difficulties with reading comprehension using traditional face-to-face teaching methods, however, studies have indicated that not all individuals with ASD have difficulties understanding inferences within text (Saldana, Carreiras, & Frith, 2009; Williamson, Carnahan, & Jacobs, 2012).

Other research has proposed that comprehension problems in ASD lie in deficits within complex cognitive processes (Randi, Newman, & Grigorenko, 2010), as proposed by Weak Central Coherence Theory (WCCT; Happe, 1999; Happe & Frith, 2006) and Executive Dysfunction Theory (EDT; Pennington, Rogers, Bennetto, Griffith, Reed, & Shyu, 1997). According to WCCT, the comprehension difficulties demonstrated by some students can be

attributed to problems in understanding main ideas and summarising and sequencing critical elements of a story (Happe & Frith, 2006; Williamson, Carnahan, & Jacobs, 2009). It is proposed by WCCT that a dysfunction in autistic perception within cognitive function is responsible for making it easier for some with ASD to process detailed (micro) over full scope (macro) information (Mottron & Bellville, 1993; Rinehart, Bradshaw, Moss, Brereton, & Tonge, 2000). Examples to illustrate this concept include visual perception tasks involving the presentation of a large numeral (for example the number 5) made up of a smaller and unrelated numerals (for example the number 8). Significant difficulties were shown by participants with ASD (Rinehart et al., 2000) as the attention of those participants with ASD favoured the smaller and unrelated numerals (the number 8) over the larger numeric representation (the number 5). The same preference was not evident in a group of matched controls (Rinehart et al., 2000). These results correlate with suggestions that visual perception in individuals with autism favours detail rather than overall visual representations (Frith, 1989; Happe, 1999; Happe & Frith, 2006; Nation, 1999). Happe and Frith (2006) explain that strengths in processing local detail could be described as a processing bias, and may provide a reason why those aspects of behaviour relating to excessive attention to detail result in difficulties in integrating text at a macro level. Difficulties in integrating information and a bias toward details may also provide explanations for disparities seen in research between component reading skills such as word recognition, fluency, and comprehension (Nation et al., 2006)

Ozonoff, Rogers, and Pennington (1991) propose that cognitive difficulties with flexibility, planning, organization, and self-monitoring lay within Executive Function (EF) in ASD. When relating this theory to reading, these dysfunctions could manifest as problems in

understanding the goal or purpose of the text. This in turn would result in an inability to read for understanding. Difficulties with the organisation of information would also mean that integrating and making connections between paragraphs in text and understanding main themes, ideas, and concepts would also be problematic (Carnahan, Williamson, & Christman, 2011).

Many teaching practitioners, speech and language specialists, and some individuals with ASD, assert that there are often strengths in visual processing over auditory perception in those on the autistic spectrum (Kunda & Goel, 2008; Kunda & Goel, 2011). As a result, visual aids such activity schedules, images, and pictures are regularly used as a teaching method to support learning a variety of skills for individuals with ASD (Knight, Sartini, & Spriggs, 2014). Recent research in neuropsychological studies indicate deficits in the auditory processing profiles of some children with ASD, which supports the perception of strengths across the visual processing domain (Roth, Muchnik, Shabtai, Hildesheimer, & Henkin, 2012). Neumann, Dubischar-Krivec, Poustka, Birbaumer, Bölte, and Braun (2011) have explained that although some individuals with ASD demonstrate an increased capacity to process simple visual stimuli, this capacity decreased as visual complexity was increased. These findings are important to consider in relation to reading, particularly when students are transitioning from visually supported texts into chapter stories, as chapter stories are not generally supported by illustrations. This transition occurs typically in middle to upper primary school.

Although many behavioural techniques employed by teachers and carers have shown success in assisting the learning and communication of children with ASD, these can be time intensive and expensive. Research relating to the use of computers and children with autism (Heimann, Nelson, Tjus, & Gillberg, 1995; Moore & Calvert, 2000) has reported higher levels of

attention, motivation, and engagement as well as providing assistance in the development of problem-solving strategies. A review of studies involving evidence based reading instruction and ASD (Whalon, Otaiba, & Delano, 2009) discusses four studies that have addressed code-focused reading skills utilising computer-assisted instruction. However, none of these studies targeted comprehension above a word focused level. (Basil & Reyes, 2003; Coleman-Martin, Heller, Cihak, & Irvine, 2005; Heimann et al., 1995; Tjus, Heimann, & Nelson, 1998). All four studies reported gains across a variety of code-reading skills such as word spelling, word recognition, sentence reading, and sentence imitation. Whalon et al. (2009) described the results of these studies as promising and suggest it is likely that computer-assisted instruction may be a viable method of learning instruction. They also indicated that there was a lack of available evidence to promote the use of computer-assisted instruction as a sole mode of support, suggesting this mode of learning be used as an augmentative measure.

With the production of new mobile technologies, such as Apple's range of i-Devices, alternative opportunities now exist for learning both inside and outside the classroom. This platform of technology could support the development of independent learning through portability and ease of use (Armstrong & Hughes, 2012). While many mainstream and special education schools across most year levels have eagerly embraced these technological innovations, research and empirical evaluation regarding actual effectiveness has been minimal, particularly in the field developmental disorders including individuals with autism (Knight, McKissick, & Saunders, 2013). Frequently, studies have reported observational or perception-based evaluations that are qualitative in nature (Hutchison, Beschorner, & Schmidt-Crawford, 2012; Knight et al., 2013; Lynch & Redpath, 2012; Saine, 2012). These regularly consist of

teacher or user accounts describing their students' motivation, engagement, and application processes. Whilst these data are valuable in providing an insight into learning experiences and user behaviours, there remains a need to investigate further empirical outcomes versus perceived benefits in order identify the specific factors which impact positively on 'academic' results (Kagohara, van der Meer, Ramdoss, O'Reilly, Lancioni, Davis, Rispoli, Lang, Marschik, Sutherland, Green, & Sigafoos, 2013; Stephenson & Limbrick, 2013; van der Meer, Achmadi, Cooijmans, Didden, Lancioni, O'Reilly, Roche, Stevens, Carnett, & Hodis, 2015).

1.6 Aims of the Research

This research is motivated by studies suggesting that computer-assisted instruction such as new mobile technologies and Apps, can aid learning in children with HFASD. Considering the evidence presented on the relationship between reading comprehension problems and the social and communicative deficits in HFASD, and the limited availability of studies involving computer-aided instruction and reading comprehension, the present study aims to answer the following questions:

> "Can App software be designed to support measurable gains in reading comprehension for students with HFASD?"

Under the primary research question sits these sub-questions:

> a. "What are the key criteria and design features to consider when creating educational software for mobile technologies?"

b."Considering the heterogeneous nature of students with HFASD, what attributes or characteristics influence students' results after using the software?"

To answer the primary research question and sub-questions the present study will:

1. Synthesise research findings on reading comprehension difficulties for students with HFASD and identify the evidence-based strategies that can support improvements;
2. Determine the main issues and features associated with the design of quality educational software;
3. Embed evidence-based reading comprehension strategies and key features of quality educational software into an interactive 'App' format;
4. Apply the App as an intervention.
5. Evaluate the effectiveness of the approach in applied settings by measuring the key factors that underpin the development of effective reading comprehension skills in students with HFASD;
6. Analyse the results and report the findings.

1.7 Implications

The present study provides insight into pedagogical approaches and strategies applied within educational settings to support reading comprehension and students with HFASD. This is particularly relevant due to the rapid adoption of iPads and tablet style computing for many children with HFASD requiring additional learning supports. Reading and understanding texts are important components of effective literacy skills which provide opportunities for accessing

information and learning, therefore, problems with comprehending text will have significant lifelong impact (National Institute of Child Health and Human Development, 2000). The results of the present study also address the need to research within and across the ASD phenotype and examine the effectiveness of specific targeted interventions with the use of technology.

1.8 A Synopsis of the Thesis

This chapter has introduced the context for the present study. In accordance with the aims outlined in this introduction (see 1.6), *Chapter 2* provides a review on the research concerning specific language and reading comprehension difficulties for individuals with HFASD. *Chapter 2* also examines the outcomes and recommendations from previous comprehension based interventions and students with HFASD, including those which incorporate computer assisted instruction. These recommendations underpin the aim and method of the present study. *Chapter 3* discusses research and key issues associated with educational software design for mobile technologies, and the theories and principles that provide the framework for the creation of the App used as the intervention for the present study. These theories and principles have been synthesised with evidence based strategies drawn from research discussed in the literature review. *Chapter 4* details the methodological approach of the present study and method. The intervention was trialled in a pilot study described in *Chapter 5* which evaluated the effectiveness of the intervention in accordance with the chosen participants and setting. Key findings from *Chapter 5* have informed the method and design of the main study and results from this study described in *Chapter 6.* A discussion on the findings of this research is provided in *Chapter 7* and synthesised with previously published literature. *Chapter 7* also discusses the

implications for practice and future research, and concludes with a synopsis of the aims, findings, and context of the study.

Chapter - 2 Literature Review

As children's oral language abilities have been identified as a factor that can impact upon reading comprehension (Bishop & Snowling, 2004; Cain & Oakhill, 2006; Nation, Clarke, Marshall, & Durand, 2004), it is important to consider the role of language for children within the ASD phenotype. Due to variations in language ability associated within a broader ASD diagnosis, it is relevant to understand the way in which language, as either expressive (speaking) or receptive (listening) vocabulary, can impact upon student's comprehension of verbal and textual information. This chapter will examine language ability and children with ASD in the context of previous studies related to comprehension and more specifically reading comprehension and students with HFASD.

2.1 Language and Autism

Autism Spectrum Disorder (ASD) is characterised by impairments in language ranging from little or no functional communication to almost typical language skills (Klinger, Dawson, & Renner, 2002; Tager-Flusberg, 2000). Setting aside considerable variations in language acquisition, it is very common that comprehension ability is more impaired in individuals with ASD than their expressive ability (Boucher, 2003). Boucher (2003) suggested that this is due to core deficits in students with ASD with a weakness in their social interaction, and their repetition or perseveration of common phrases and words. Even so, the only aspect of language that is considered to be universally impaired across the spectrum is the pragmatics of language (Lord & Paul, 1997; Tager-Flusberg, 2000). Pragmatics of language refers to using communication skills,

for example understanding how to use language for different purposes; making changes or adjustments according to the needs of the situation or audience, and following rules and conventions, such as knowing how to use verbal and non-verbal conversation cues. Typically, pragmatic difficulties result in the misinterpretation of words and speech such as applying understanding to the literal, rather than the contextual or inferential meanings of words (Grynszpan, Martin, & Nadel, 2008). One of the paralinguistic aspects of pragmatic language is prosody which is the way that pitch, tone, and modulation are applied to speech to convey emphasis or meaning (Crystal, 1969). Prosodic abnormalities often associated with individuals with ASD can be described as speech that is parroted, over-exaggerated, monotonic, or at an atypical pitch, rhythm or intonation (Järvinen-Pasley, Peppé, King-Smith, & Heaton, 2008). For example, based on 31 children with autism, aged from 6 – 13 years, Peppé, McCann, Gibbon, O'Hare, and Rutherford (2007) reported significantly lower prosodic performance in expressive and receptive abilities, relative to their peers without ASD. This difference between the two groups was more evident at a phrasal rather than at single-word level. Because many children with ASD also demonstrate oral language impairments, Nation and Norbury (2005) explained that for these children, "difficulties with reading comprehension are perhaps to be expected" (p. 25).

Research investigating the development of language in ASD has often examined the relationship between expressive and receptive vocabulary. Hudry, Leadbitter, Temple, Slonims, and McConachie (2010) found atypical patterns of receptive and expressive vocabulary amongst 30% of pre-schoolers with ASD from an overall sample size of 152. These measures were taken using the "MacArthur Communicative Development Inventories" (Fenson, Dale, Reznick, Thal,

Bates, Hartung, Pethick, & Reilly, 1993). The results described receptive vocabulary as more impaired than expressive language abilities. Similar patterns in early development were also noted by Ellis Weismer, Lord, and Esler (2010) in a study of receptive and expressive language deficits in children diagnosed with ASD aged between two and three years. In contrast, despite finding a proportion of higher standard scores in the expressive language domain than in the receptive, Kjelgaard and Tager-Flusberg (2001) concluded that on average, children with autism do not display discrepancies in receptive and expressive vocabulary ability.

More recent research has sought to examine if receptive language may be a relative weakness for individuals with ASD and to characterise specific vocabulary profiles (Kover, McDuffie, Hagerman, & Abbeduto, 2013). Vocabulary ability was assessed using the "Peabody Picture Vocabulary Test", Fourth Edition (PPVT-4; Dunn & Dunn, 2007) and "Expressive Vocabulary Test", Second Edition (EVT-2; Williams, 2007) in 49 boys with ASD aged between 4 and 11 years. Kover et al. (2013) concluded that on average the receptive vocabulary of school-age boys with ASD is delayed relative to chronological age and delayed in trajectory relative to expressive vocabulary when measuring vocabulary growth. In examining the results, it was reported that nine boys had significantly *lower* standard scores on the PPVT than the EVT. In contrast, five of the boys had significantly *higher* standard scores on the PPVT than the EVT. Statistically significant differences were seen at a .05 level relative to the norming sample (Williams, 2007). Measured against typically developing boys matched on age-equivalent scores and non-verbal ability, the participants with ASD showed deficits in receptive and expressive performance in almost all areas of comparison. Williams (2007) noted that receptive levels were also identified to 'lag' behind expressive vocabulary even as children with ASD progressed in

age. This notion that receptive language levels 'lags' behind expressive language and that the gap does not fully close with age is an interesting result when examined in tandem with other weaknesses such as comprehension.

2.2 Language and Comprehension - General

Investigating the relationship between spoken language skills and poor comprehension Nation and Snowling (2004) examined the speech and language abilities of 25 eight to nine year old children with poor reading comprehension through assessments made using the "Neale Analysis of Reading Ability Revised" (Neale, 1997). Nation and Snowling showed that in comparison to children in the control group, the children with poor reading comprehension displayed less skill in the use of word knowledge, vocabulary, language use and tense. In addition, decoding abilities were measured by testing of non-word reading skills from the standardised "Graded Non-word Reading Test" (Snowling, Stothard, & McLean, 1996). The study administered a battery of tests covering phonological, semantic, morphosyntax, and broader language skills. In summary, Nation and Snowling (2004) revealed similar findings to other studies (Cain, Oakhill, & Bryant, 2000; Nation & Snowling, 1998; Ricketts, Nation, & Bishop, 2007), showing minimal evidence of deficits between children with proficient reading comprehension and those children with poor reading comprehension in terms of phonological processing, phonological awareness, and non-word repetition. The children with poor comprehension had more weaknesses with oral language skills and, as expected, reading comprehension. Nation and Snowling (2004) suggested that children's strengths across the phonological domain may be responsible for fluent decoding and word reading ability, and weaknesses with structural aspects of language could be responsible for deficits in

comprehension. Therefore, it could be argued that effective word recognition is underpinned by normal levels of phonological processing and reading comprehension is constrained by deficits in oral language. Considerable variation was seen across the tests with no clear profile constructed that would encompass all participants with poor comprehension tested. From the results of this study, it was not possible to determine if weaknesses in oral language create problems with comprehension, or poor comprehension impairs the development of oral language, or both are interacting on each other. The interaction between oral language and comprehension was explored in a longitudinal study by Nation, Cocksey, Taylor, and Bishop (2010). These researchers examined the early language skills of 242 children at school entry age and retested the same children again when they were in mid-childhood. This was to determine the relationship between oral language weaknesses and reading comprehension over time. Nation et al. identified that the children's language profiles were similar at mid-childhood to those made at school entry age, indicating that while language improvements did occur, the pattern of oral language impairments persisted through childhood. The study design allowed the researchers to assess the children's oral language skills before they were able to read. The findings highlighted that in most cases the children's weaknesses in oral language were present and consistent throughout childhood, and preceded the children's comprehension deficits.

Similarly, Cain and Oakhill (2006) sought to identify if a specific 'profile' contributed to problems associated with reading comprehension. The vocabulary, word-reading accuracy, and cognitive ability of 23 children with poor reading comprehension was examined comparatively to 23 children with strong reading comprehension at age 8 then again at age 11. They concluded that a single underlying source of poor comprehension was unlikely and suggested that research

and practice should proceed cautiously in making group comparisons, as these may mask other underlying cognitive or language weaknesses in an individual profile. Importantly, Cain and Oakhill (2006) indicated that research into understanding the development of comprehension may be better understood by investigating the interaction between cognitive abilities and language skills, rather than a focus on specific lower or higher-level reading skills. On this point, Oakhill and Cain (2007) identified for children with ASD, sentence and whole text comprehension aligned more closely with their oral language skills and their verbal ability, particularly, in the middle to upper primary age.

2.3 Language and Comprehension for Children with Autism

Literature concerning the reading ability of children with ASD has generally correlated problems in reading comprehension with the language and communication deficits associated with the disorder (Smith-Gabig, 2010). The association between poor oral language skills and problems in reading comprehension has already been established in typically developing children (Bishop & Snowling, 2004; Cain & Oakhill, 2006; Nation et al., 2004). Despite the language and communication deficits related to the disorder, many studies have noted that children with ASD, particularly those considered 'high-functioning' (HFASD), may still develop phonological awareness or an understanding of the structure of words at age appropriate or above levels (Mayes & Calhoun, 2003; Saldana et al., 2009).

Nation et al. (2006) examined the reading capabilities of children diagnosed with autism and a number of inclusive diagnoses. Participants included those identified as Asperger Disorder, Pervasive Developmental Disorder – Not Otherwise Specified (PDD-NOS), and

autism. Participants were recruited from 6 years of age upwards to 15 years, with 'measureable language skills.' More broadly, the data showed reading accuracy within a normal range and comprehension as lower, however, significant variations in test performance was noted. The results also showed both floor (lowest range on the test) to near ceiling (highest range on the test) levels within the group on some tasks, which meant that the results were not that informative regarding the students' 'true competence' as measured on that test of reading skills. These data did however illustrate the heterogeneous nature of reading ability across the spectrum. A large proportion of children within the Nation et al. study displayed reading comprehension impairments ranging from one standard deviation below population norms, to very severe reading impairment. Nation et al. indicated that these results may, in part, stem from the children's inadequate reading accuracy. Even so, of the 20 children who achieved normal range word reading skills, half showed poor comprehension which could not be attributed to problems with reading accuracy. These children also displayed oral language, vocabulary and comprehension impairments which Nation et al. suggested were related to general understandings of language (Bishop & Adams, 1990; Nation et al., 2004). The study did not examine the general intelligence (IQ) levels of the participants. Thus, any underlying cognitive processing deficits associated with the children could not be ruled out in this instance. These could have offered an alternative explanation for the variability and extremes in results. Given that most of the participants in this study showed an average word reading ability in relation to age, Nation et al. reported that many participants had difficulties in deciphering non-standard English words. Non-standard English words are groups of letters that require phonological decoding by using letter-sound correspondence, for example sut, mot, ip. It is relevant to note that in reference to these findings, nine, or 22% of the youngest children involved in this study

were unable to read basic sight words. In contrast to the Nation et al. research, others studies have identified strengths in non-standard English word reading in students with ASD (ie., Frith & Snowling, 1983; Minshew, Goldstein, Taylor, & Siegal, 1994; Newman, Macomber, Naples, Babitz, Volkmar, & Grigorenko, 2007; O'Connor & Klein, 2004). The participants from these studies are described as children with High-Functioning Autism (HFASD) with general intelligence (IQ) levels at or above average. These findings suggest that phonological decoding may not always be responsible for the reported deficits in reading comprehension for students with HFASD.

More recently, Norbury and Nation (2011) investigated the role of structural language skills and the relationship between oral language comprehension, word reading ability, and students with ASD. They examined the hypothesis that poor structural language could predict problems in reading comprehension and word reading ability for students with ASD. This study recruited 27 adolescents with ASD but with different language phenotypes, and a cohort of similar age students without ASD as the control contrast group. This research was framed in reference to the simple view of reading proposed by Gough and Tunmer (1986). The simple view of reading identifies two core skills in the reading process, the decoding of the words and the comprehension of those words in text. This focus on decoding and comprehension is widely accepted as one method of categorising the range of difficulties many children encounter with reading (Woolley, 2011). In this instance, the simple view of reading was incorporated with the model proposed by Bishop and Snowling (2004) which suggested more specifically that it is children's phonological and non-phonological skills that support their comprehension and decoding. Although the Norbury and Nation (2011) results showed considerable variation

across students with the ASD phenotype, the data indicated that deficits in oral language were related to comprehension problems for students with ASD and for students without ASD, who showed comprehension and language impairments. It is important to note, however, that Norbury and Nation (2011) maintained that these results did not account for all variations in reading comprehension deficits for children with ASD. They suggested that cognitive processing difficulties associated with students with ASD may be an issue. The claim is that students with ASD are more likely to process local, literal, and immediate information over global and more abstract information, as hypothesised in the "Weak Central Coherence Theory" or the "Executive Function Theory" (ie., Happe, 1999; Jolliffe & Baron-Cohen, 2000; Pennington et al., 1997).

Research examining the language performance in children diagnosed with ASD has shown that even with normal development of linguistic skills, language comprehension skills can be impaired (Goldstein, Minshew, & Siegel, 1994; Saalasti, Lepistö, Toppila, Kujala, Laakso, Nieminen-von Wendt, von Wendt, & Jansson-verkasalo, 2008). Saalasti et al. (2008) investigated specific deficits in language and students with HFASD in order to ascertain if these deficits could contribute to associated communication deficits. Participants recruited for the study were children who met the ICD-10 (World Health Organization, 1993) criteria for Asperger Syndrome or HFASD. Sixteen boys and six girls with a mean age of 8.9 years were matched with typically developing controls on age, gender and general intelligence (IQ). Participant's language skills were extensively measured by testing: vocabulary and naming abilities; linguistic short term memory; verbal fluency; phonological knowledge and processing; and comprehension of instructions and sentences. In addition, auditory processing was also evaluated by measuring

the comprehension of sentences under different conditions. These conditions comprised of two different types of background noise.

The participants with HFASD performed similarly to controls on tests of semantic and fluency, however, the most significant differences between the children with HFASD and the children without HFASD was on a subtest for comprehension of instructions. These results indicated that when compared with typically developing children, those students with HFASD showed more difficulty following verbal instructions. This could indicate that many of these children had deficits in receptive vocabulary as raised by Kover et al., (2013). In addition to language skills, Saalasti et al. (2008) noted that students' ability to follow verbal instructions is influenced by their short term memory, spatial perception, motor planning, and attention skills. Saalasti et al. (2008) suggested that lower performance of the students with HFASD on this subtest could possibly be due to deficits in short-term working memory, as well functioning working memory skills. Working memory is required for the successful selection, maintenance and manipulation of information in order to perform an action (Baddeley, 2000). While working memory may be an issue, it could not be the only factor, because both students with and without HFASD obtained similar scores on the "Sentence Recognition" subtest, which measured auditory short-term processing and working memory functioning. Saalasti et al. (2008) concluded that deficits in short term memory could not alone account for significantly lower performance in the comprehension of instructions test.

Although not statistically significant, results on the "Phonological Processing" subtest showed group differences with lower scores recorded by the HFASD group in comparison to students without HFASD. Saalasti et al. proposed that these differences may be indicative of some level of deficit in Executive Function for students with HFASD. Executive Function skills

are required for the planning, self-regulation and execution of motor action after linguistic information has been processed.

In a related study, Joseph, McGrath, and Tager-Flusberg (2005) reported deficits across all three domains of Executive Function including; working memory; inhibitory control; and planning in children diagnosed with ASD. Additionally, results showed language skills were less developed in the participants with ASD. When Executive ability for students with ASD was correlated to their language ability, no relationship was attained. In contrast, a positive correlation was shown between language ability and Executive performance of children without ASD. In summary Joseph et al. proposed that no direct relationship between Executive dysfunction and language impairment existed in autism, rather they interpreted their results as a deficit in the use of oral language skills necessary for rehearsal and coding of instructions required to successfully complete a task. This is in contrast to the findings by Saalasti et al. (2008) which identified only subtle differences in receptive language between typically developing controls and the participants with HFASD. The distinction between the Saalasti et al. (2008) and the Joseph et al. (2005) findings could be a cohort variance when students with HFASD are compared to students with ASD. These differences suggest that further research is still needed to investigate the interaction between receptive language, social behaviour, and communication in students with HFASD. For example, how receptive language may impact on students with ASD and HFASD and their social behaviours and communication ability, and how communication and social behaviour may impact on language skills and development of students with ASD and HFASD.

Studies investigating language and individuals with ASD have examined the relationship between skills involving word recognition, oral language comprehension and social behaviour

(Jones, Happe, Golden, Marsden, Tregay, Simonoff, Pickles, & Charman, 2009; Ricketts et al., 2013). Jones et al. (2009) and Ricketts et al. (2013) reported positive correlations between levels of social competence, reading comprehension, language and test results for performance intelligence (PIQ). Performance intelligence is the non-verbal component of a general intelligence (IQ) test, while the other main component is verbal intelligence (VIQ). Jones et al. (2009) and Ricketts et al. (2013) suggested that for children with ASD, measures of social behaviour and social cognition may be important factors relating to their problems with reading comprehension, given that these children's scores on performance (non-verbal) intelligence were not a strong predictor of their reading comprehension. These findings relate well to the Norbury and Nation (2011) research which identified that even after controlling for word recognition, the most significant predictor of reading comprehension for children with ASD was their oral language comprehension ability. There is also support for this statement from related studies for students with and without ASD, for example Hoover and Gough (1990) and Nation et al. (2006). Ricketts et al., however, suggested that as Norbury and Nation (2011) included students without ASD in their analysis, it is not necessarily clear that it is word recognition and oral language alone which are specific determinants of reading comprehension success for students with ASD. Ricketts et al. argued that in order to better understand the nature of reading comprehension deficit or success for students with ASD, future studies need to move beyond the simple comparison of different groups (ASD vs. dyslexia, ASD vs. typically developing controls). Rather, future research needs to better understand the mechanisms directly related to the formation of reading comprehension for students with ASD and identify teaching and learning strategies to enhance student competencies in reading comprehension. Ricketts et al. noted that even after accounting for differing ability in word recognition and oral language, measures of

social cognition and behaviour could still predict variations in reading comprehension for students with ASD. This finding is consistent with other studies involving students with ASD (i.e., Lindgren et al., 2009; Nation et al., 2006), that impairments in social communication and social relationships can also play a role in problems with reading comprehension and students with ASD.

2.3 Autism and Hyperlexia

The term hyperlexia, although not strictly defined, is characterised by the presentation of exceptional word-reading ability above what would be expected from measures of non-verbal intelligence and at a higher level than the ability to comprehend text (Aram & Healy, 1988; Cobrinik, 1982; Goldberg & Rothermel, 1984). That is, the reader's ability to decode and say words is higher than the reader's ability to comprehend the meaning of those words in text (Silberberg & Silberberg, 1967, 1969). Silberberg and Silberberg first used this term as a description for children who acquired word reading-decoding abilities from average to high proficiency despite cognitive disability. In addition to this description, with reference to readers with ASD, are other reported behaviours such as compulsive reading practices, obsessive attachment to books, and an intense interest in environmental literature (Newman et al., 2007). These other reading behaviours are not unique to students with ASD, or to students with ASD who demonstrate some level of hyperlexia (Saldana et al., 2009). As some children with HFASD often present with outstanding word reading abilities in tandem with lower comprehension comparative to their verbal functioning or cognitive levels, some studies have sought to clarify if this characteristic could be an identifying factor of HFASD (Fisher, Burd, & Kerbeshian, 1988).

It has been suggested that the oral language deficits observed in children with ASD is 'mirrored' in their related problems with semantic representations of the text (Frith & Snowling, 1983). This differentiation of higher decoding ability and lower comprehension ability concerning individuals with HFASD was also reported by Minshew et al. (1994), Szatmari, Tuff, Finlayson, and Bartolucci (1990), and Newman et al. (2007).

Research into the word reading abilities of school-aged children with ASD has described very broad variations in capability (Åsberg & Dahlgren Sandberg, 2012; Nation et al., 2006; Norbury & Nation, 2011). For instance, a pattern showing strengths in word reading ability in relation to 'mental' general intelligence age was noted by Grigorenko, Klin, Pauls, Senft, Hooper, and Volkmar (2002) from within a clinical sample of children with ASD. This is similar to the findings of Jones et al. (2009) who described strengths in word reading relative to general intelligence for many adolescents with ASD across a population-based sample. As already noted, Nation et al. (2006) reported that some participants showed accurate reading ability in combination with very poor comprehension, which was considered consistent with a hyperlexic profile when investigating patterns of reading ability in children with ASD. Nation et al. concluded that deficits in reading comprehension appear to accompany impairments in comprehension of language in general. In a related study, Johnels and Miniscalco (2014) investigated the exceptional word-reading ability of a seven year old boy with ASD. Their findings identified that the participant demonstrated very strong visual attention skills together with normal to strong phonological abilities which may underpin demonstrated strengths in word reading. This was despite the participant's weaknesses across oral semantic, syntactical, and narrative language tests.

2.4 Reading Instruction for Individuals with ASD

The literature concerning interventions that involved specific skills supporting reading comprehension in ASD are mostly studies that are small in scale with few participants (El Zein, Solis, Vaughn, & McCulley, 2014; Whalon et al., 2009). A recent synthesis on reading intervention studies involving students with ASD from kindergarten to Year 12 (El Zein et al., 2014) identified 12 published studies that met their inclusion criteria for reading comprehension interventions and students with ASD. These were studies conducted between 1980 and 2012, peer reviewed, and included single-subject, single-group, experimental and quasi-experimental designs all utilising a dependent measure of reading comprehension. Four studies implemented strategy instruction (Åsberg & Sandberg, 2010; Stringfield, Luscre, & Gast, 2011; Van Riper, 2010; Whalon & Hanline, 2008), and three utilised explicit instruction, for example question generation, making predictions and the use of graphic organisers (Flores & Ganz, 2007; Ganz & Flores, 2009; Knight, 2010). A further three studies examined student grouping practices (Kamps, Barbetta, Leonard, & Delquadri, 1994; Kamps, Leonard, Potucek, & Garrison-Harrell, 1995; Kamps, Locke, Delquadri, & Hall, 1989), and another two investigated referents within text through anaphoric cueing instruction (Campbell, 2010; O'Connor & Klein, 2004). Anaphoric cueing instruction involves the resolution of the ambiguity in the use of pronouns such as he, she, someone, and everyone. For example, this would involve explicit prompting when conducting reading instruction to refer the reader from the pronoun (anaphor) back to the original person, place or object such as Peter, Jane, or Sam, Jack, and Harry. These interventions covered the range of strategies that are typically applied to remediate and support reading comprehension for all students. These strategies are covered in further detail in this chapter section 2.4.

Not included in this synthesis was a 'grounded theory' study that investigated the ways in which students with HFASD comprehend text and the factors that may influence comprehension for these individuals (Williamson et al., 2012). Based on the understanding that students with ASD have a 'different' way of interacting with and focusing on text as suggested by the theoretical frameworks of "Weak Central Coherence Theory" (WCCT; Happe, 1999; Happe & Frith, 2006) , "Theory of Mind" (ToM; Baron-Cohen et al., 1985; Frith, 1996) and "Executive Function Theory" (EFT; Happe, 1999; Jolliffe & Baron-Cohen, 2000; Pennington et al., 1997), Williamson et al. (2012) provided the participants with explicit daily reading instruction. This instruction included remedial strategies such as 'think-alouds' where the reader vocalised what strategies they were using as they read the text. This 'think-aloud' strategy was video modelled, so that the students had both a visual and an auditory model to review. The use of a video to display and a way to reinforce the strategy Bell and Bonetti (2006) referred to as 'visualising and verbalising.' Bell and Bonetti (2006) claimed that this duel processing helped students to gain more insight into their own thinking process and use of strategies. Williamson et al. (2012) asked the participants a range of questions to determine if they were accessing background knowledge associated with the text. Participants were also asked to talk aloud to represent their thoughts verbally as they read the texts, to write about the read text, and to draw pictures as mental representations. With a total of 13 participants, three different profiles emerged in the way meaning is made from text. Williamson et al., described these profiles as "text bound comprehenders, strategic comprehenders, and imaginative comprehenders-" (p. 464). Text bound comprehenders were those described as having difficulties in accessing relevant background knowledge to support the development of text based comprehension. Even despite these differing profiles, Williamson et al., made the point that teaching comprehension strategies

to students with HFASD needs to be planned for and reinforced through systematic practice. They claimed that comprehension interventions need to be explicitly taught and require a teacher to provide students with HFASD with the strategies and structures to allow access to their prior knowledge about the text, and to assist in making connections concerning the read text and their existing knowledge.

2.4.1. Co-operative learning groups

Whalon et al., (2009) reviewed 11 studies involving children with ASD that targeted the five areas of reading instruction as recommended by the National Reading Panel (NRP; National Institute of Child Health and Human Development, 2000). These studies indicated that children with ASD can gain benefit from the five areas of reading. These five areas include; phonemic awareness, phonics, oral reading fluency, vocabulary, and comprehension strategy instruction. Studies concentrating on meaning-focused interventions (Dugan, Kamps, Leonard, Watkins, Rheinberger, & Stackhaus, 1995; Kamps et al., 1995; O'Connor & Klein, 2004; Rosenbaum & Breiling, 1976; Whalon & Hanline, 2008) have used both peer mediated support and one-to-one instruction techniques. Dugan et al. (1995) and Kamps et al. (1994) incorporated cooperative learning groups and included strategies such as peer tutoring and team worksheets. Some teachers reported positive gains, although the results for academic gains as seen in other studies were more mixed and not clearly conclusive. This suggests that there could be a number of teacher, student and programming variables involved when investigating programs to enhance the reading comprehension of students with ASD (Rose & Grosvenor, 2013; White & Smith, 2002).

Working with participants in a mainstream educational setting, Whalon and Hanline (2008) randomly assigned participants with HFASD to one of three general classroom peers to read and work in pairs. These reading pairs were rotated each successive day and students were taught to respond to and generate questions regarding a story's characters, setting, events, problems, and solutions. Each participant in the pair took turns reading a book aloud in the initial session, with 'prompting' from the researcher to model the process required to respond to, and generate questions. This allowed the process to be scaffolded and encouraged the students to consider what cues in the text would help to generate a possible question. In the subsequent sessions, participants used visual check-lists and storyboards to monitor their own progress in comprehension of the read text. The Whalon and Hanline (2008) study reported gains in the students' ability to generate questions and to respond to questions about the text. The researchers noted that overall, improvements demonstrated by the students with HFASD increased to similar levels as their peers. Whalon and Hanline (2008) suggested that the intervention could have been conducted over a more extended period of time so that all participants could be followed up to ascertain if the positive gains that were noted could be maintained independently over time.

2.4.2. Anaphoric Instruction for Pronouns in Text

O'Connor and Klein (2004) selected 20 participants identified as having HFASD with standardised reading comprehension scores significantly lower than their word identification scores to investigate ways of supporting the students' understanding of text. They identified three areas which may be problematic for individuals with autism which were: (1) difficulty in integrating information; (2) resolving anaphoric references; (3) and engaging prior knowledge. In

this study, the teacher or researcher used prompting to assist the participant with the task, with the goal of removing the teacher's prompts over time to ascertain if the reading behaviour could be maintained and continued independently by the reader. The study selected three reading strategies on the basis of their relevance in targeting comprehension problems at sentence and paragraph level. The three strategies were chosen from previous research which had demonstrated that individuals with HFASD show difficulties in producing and referring to pronouns in speech (Fine, Bartolucci, Szatmari, & Ginsberg, 1994), and some in accessing prior knowledge required to interpret a text (Pressley & Afflerbach, 1995). The three main strategies employed were: (1) pre-reading questions to prime existing knowledge or activate information from long term memory in order to create a 'schema' or context for the passage to be read; (2) anaphoric cuing, which is relating pronouns back to antecedent nouns; and (3) 'cloze' tasks in which students make predictions about the text as they are reading. In summary, O'Connor and Klein (2004) described results which indicated that the most significant medium sized gains in participants' comprehension were accounted for by the facilitation involving anaphoric cuing, with smaller and not statistically significant results from the other two facilitations. Similarly, Campbell (2010) reported gains in comprehension for 21 students with ASD after participating in a ten week bi-weekly program focussed on anaphoric cueing. The program provided anaphoric questions with the provision of textual prompts used as a scaffolding technique to assist the reader in identifying the correct pronoun referent within the text.

2.4.3. Scaffolded Instruction and Direct Instruction

Repeated storybook reading with adult scaffolding has shown benefits as an effective intervention for children with learning disabilities as a means to improve fluency and support comprehension (Meyer & Felton, 1999; Therrien, 2004). Bellon, Ogletree, and Harn (2000) used verbal scaffolding strategies such as cloze procedure, binary choices (offering alternative language choices – modelled), 'Wh' questions, and expansions (elaborations on child responses) to successfully improve the use of spontaneous language in a single subject case study for a student with HFASD. Over a treatment period of seven weeks, the participant demonstrated steady decreases in perseverative verbal behaviours and echolalia and increased use of spontaneous language. Although this study was limited by the number of participants (one), repeated readings and scaffolded instruction have been incorporated with other reading comprehension strategies into interventions for students with HFASD who have shown improvements in comprehension (Armstrong & Hughes, 2012; Whalon & Hanline, 2008).

Intervention studies that have utilised explicit or direct instruction interventions to assist students with reading comprehension have investigated strategies such as scripted directions, explicit signals to elicit responses, choral responses, and the provision of independent practice (Flores & Ganz, 2007; Flores, Nelson, Hinton, Franklin, Strozier, Terry, & Franklin, 2013; Ganz & Flores, 2009). These studies have indicated gains by students across several strands including using inferences, facts and analogies, and demonstrated maintenance of performances after a period of not receiving the intervention. Similarly, Knight (2010) implemented explicit instruction and prompting techniques using three different treatment conditions for four participants described as being diagnosed with mild to moderate ASD (HFASD). These included; supported electronic text; supported electronic text with explicit prompting; and

supported electronic text with explicit prompting and definitions of unfamiliar words. The findings of this study reported the results as effective for one participant, questionable or indeterminable for another, and ineffective for the remaining two (El Zein et al., 2014). These findings were determined from researcher-developed digital quizzes used as an independent variable, with dependent variables of reading fluency and broad reading ability. As Knight (2010) did not collect data regarding participants' levels of language and verbal intelligence, it was difficult to determine a specific reading profile for each participant. These factors are important when considering the close association between oral language ability and comprehension in determining the impact of each intervention on students with differing ASD language profiles (Bishop & Snowling, 2004; Nation et al., 2004; Norbury & Nation, 2011).

2.4.4. Visual Strategies

Individuals with ASD are often reported to be more visual learners (Knight et al., 2014; Kunda & Goel, 2008; Kunda & Goel, 2011) or to demonstrate a visual over auditory processing bias (Neumann et al., 2011; Roth et al., 2012). As a consequence, strategies that support visualisation have been shown to be beneficial for assisting learning for students with ASD. Visual Activity Schedules (VAS) have been used successfully and very regularly for teaching skills such as daily living routines, and to improve social behaviours (Carlile, Reeve, & Reeve, 2013; Cuhadar & Diken, 2011; Waters, Lerman, & Hovanetz, 2009). Visual schedules have also shown positive results for individuals with HFASD who were taught to use graphic visual structures to organise information and create connections within read text (Bethune & Wood, 2013; Gately, 2008). As already mentioned, Whalon et al. (2009) used visual cue cards with

paired script instruction to enhance the comprehension of students with HFASD. It has been proposed by researchers that providing visual supports for learners reduces demands on cognitive processing loads (Joffe, Cain, & Maric, 2007). Woolley (2010) claimed that using a combination of visual and verbal reading strategies such as those proposed by Bell and Bonetti (2006) assists students in mastering a reading and comprehension task. Over time, the external visual cue can be faded as the reading strategy becomes internalised by the student. Even as using a combination of visual and verbal strategies could be considered initially to be an attention-demanding process, it can "become automatic through explicit instruction and practiced on a variety of texts," in developing independent practice (Woolley, 2010, p. 111).

Providing illustrations in text can also assist readers to improve meaning and enhance comprehension when students are prompted to attend to pictures in text (Duke & Pearson, 2002; Van Meter, Aleksic, Schwartz, & Garner, 2006). Glenberg and Langston (1992) explained that 'good' illustrations are able to assist less experienced readers in providing information that is not directly or explicitly written into text. Furthermore, Van Meter et al. (2006) highlighted that there was a difference between the provision of illustrations in text and the construction of visual images through drawing. They suggested that drawing can improve students' reading comprehension as this enables the reader to better organise textual information. For example, when readers are provided with an opportunity to draw, they are able to select specific story elements to construct new mental representations to integrate with their existing knowledge of the topic. If the reader engages with text for which they have no stored visual imagery, verbal descriptions can usually allow them to construct their own imagery of the read text. Visual images may be more relevant for individuals with ASD and HFASD as they help supplement and

compensate for possible weaknesses in their cognitive information processing (Bauminger-Zviely, 2013). For students with HFASD, their possible information processing difficulties are linked to three other difficulties: (1) understanding the intentions or mind state of others; (2) the organization of textual information and; (3) focusing on detail over integration of information at sentence and paragraph levels of the text. These three difficulties are all possible reasons why students with HFASD have difficulties with text cohesion, which in turn impacts negatively on their comprehension. Therefore, providing individuals with ASD, particularly those at a high-functioning level who are fluent readers and decoders, with opportunities to practice the construction of mental imagery may support comprehension through consistent practice of this strategy. A supported process, such as teacher modelling and prompts through the provision of visual frameworks, could assist students with HFASD to ultimately use these visual strategies independently to enhance their reading and comprehension (Carberry, 2014).

2.5 Computer Assisted Technology

Studies involving computer assisted instruction and students with ASD are not a recent field of research, with the first such published studies appearing in the literature more than forty years ago (Colby, 1973). Since this time, new advances in technology have provided opportunities for many students with developmental disorders such as those with ASD to utilise this mode of instruction to support the development of knowledge and skills. The use of technology-based interventions appears to provide the systematic instruction that is required for students with ASD (Lang, Regester, Rispoli, Pimentel, & Camargo, 2010).

Knight et al. (2013) conducted a comprehensive review of literature published between 1993 and 2012, in order to evaluate which technology-based interventions could be considered as evidence-based in teaching academic skills to individuals with ASD. Single-subject research and group experimental design studies were examined. From a total of 25 studies meeting inclusion criteria, only three single-subject and none of the group experimental design studies could demonstrate meeting quality indicators, as stated by Gersten, Fuchs, Compton, Coyne, Greenwood, and Innocenti (2005) and Horner, Carr, Halle, McGee, Odom, and Wolery (2005), to guide the quality of research in the field of special education. While acknowledging that there were some weaknesses in the design of the 25 studies reviewed, Knight et al. (2013) concluded that the use of technology to teach academic skills should be incorporated into a program of student instruction. They argued that the quality of some studies meant that practitioners need to be cautious concerning some findings until such time as more studies meeting quality indicators, such as those stated by Gersten et al. (2005) and Horner et al. (2005), are added to the research base.

Looking specifically at technology and reading for students with HFASD, Armstrong and Hughes (2012) implemented a single subject intervention design that investigated the impact of repeated reading interventions using computers and storybooks on the comprehension of five students identified as HFASD. The five participants were selected on the basis of their strong lexical and cognitive skills. The intervention involved independent 'read-aloud' and 'read-along' strategies as both of these evidence-based strategies have shown to increase word accuracy, expression and comprehension abilities (Meyer & Felton, 1999; National Institute of Child Health and Human Development, 2000; Therrien, 2004). The intervention involved 20 sessions

in total with comprehension scores charted daily in order to identify trends. The data showed that three of the five participants produced higher than expected results on comprehension questions during each intervention. The remaining two showed no significant changes in comprehension levels. Armstrong and Hughes (2012) noted that the three participants who made the most gains in comprehension had shown higher working memory results in baseline subtests involving number repetition, digit span forward and backward, and sequencing. These participants had also demonstrated higher levels of expressive and receptive language in baseline testing. Armstrong and Hughes also varied how the intervention was delivered as all participants had engaged in different delivery modes of the repeated reading intervention (computer and storybook) in a randomised format. They could not identify if it was the randomised format that made a difference in the participants results, however, suggested that it was the students' readiness to respond to the intervention that was a critical factor. In conclusion, they argued that more research was needed regarding comprehension strategies, technology and students with HFASD.

With the introduction of new mobile technologies into mainstream and special education, research is now emerging on the use of related touch screen devices such as the iPod, iPhone or iPad in intervention studies in the field of developmental disorders (Kagohara et al., 2013; Stephenson & Limbrick, 2013). Kagohara et al. (2013) conducted a systematic review of empirical studies that involved interventions designed to increase academic, communication, social, and other adaptive behaviours using these new mobile devices. The majority of the 15 studies that were identified involved students diagnosed with ASD and severe intellectual disability, however, only one study examined the use of an iPad for teaching academic skills.

This study involved two children diagnosed with Asperger Syndrome and attention deficit hyperactivity disorder and used a video modelling approach to teach the students how to use the spell-check function of a word processor (Kagohara, Sigafoos, Achmadi, van der Meer, O'Reilly, & Lancioni, 2012). The results of the 15 identified studies were mostly positive and support the potential value of incorporating these types of technology as genuine learning aids for individuals with developmental disorders. Even so, Kagohara et al. (2013) highlighted that existing literature had involved in most cases a small number of participants, and note that there had not yet appeared to be any studies indicating that iPad-based Apps have actually resulted in improved academic outcomes in critical curriculum based areas such as literacy. This reported deficit in the literature as identified by Kagohara et al. (2013), is important to acknowledge and certainly argues for the need for more research involving iPads, reading comprehension and students with ASD and HFASD.

More recently, van der Meer et al., (2015) used App software as an intervention to conduct an experimental design study for a male participant aged 10 years diagnosed with ASD and highly impaired communication. The study measured improvements in picture/word matching activities on the iPad. A multiple baseline across matching tasks design was used with a sequence of phases: baseline, intervention, follow-up, and random order. The results extend previous research with iPads and Apps such as Kagohara et al. (2012). The van der Meer et al., study also employed strategies using graduated guidance and differential reinforcement (Duker, Didden, & Sigafoos, 2004) to improve the student's picture/word matching skills. The positive results of this intervention have further reinforced the potential benefits for the use of mobile technology in educating students with ASD. Even though the study did not investigate whether

the participant was able to generalise the learned skills and apply them to novel picture/words, van der Meer et al. (2015) proposed that this may have been possible, taking into account the measured improvements which resulted in a higher level of correct responses. To date, studies have shown that the use of iPads can teach discrete academic skills (in this instance word and picture matching). The question then is, can iPads move beyond teaching discrete academic skills to support more complex literacy tasks for students with ASD and HFASD, including the demonstration of measurable gains? It is this question that is at the core of this thesis.

2.6 Summary

One of the difficulties in understanding why some students with HFASD show positive gains with interventions and others do not, could be in part due to the selection of dependent variables. Research concerning students with HFASD has explored the association between language in the form of expressive/receptive vocabulary, decoding, fluency, phonological awareness, and how these factors may impair a student's reading comprehension (Bishop & Snowling, 2004; Cain & Oakhill, 2006; Nation et al., 2004; Norbury & Nation, 2011; Saldana, 2009). As such, it would appear relevant and necessary to include these factors as dependent measures when evaluating why an invention concerning reading comprehension is a success for one student with HFASD and not for another student with HFASD. This is the purpose for incorporating these measures into the methodology of the present study (see *Chapter 4)*.

Studies investigating reading comprehension instruction and students with HFASD have often utilised face-to-face instructional techniques (Bellon, Ogletree & Harn, 2000; Campbell, 2010; Dugan, 1995; O'Conner & Klein, 2004; Whalon & Hanline, 2008). The social and

emotional deficits of students with HFASD and other factors such as teacher and student programming and traditional face-to-face teaching techniques can also make it difficult to determine why outcomes are positive for some students with HFASD and not for others. These are some but not all of the factors likely to have had impact upon the findings of studies which have shown mixed results. Technology-based interventions by nature can inherently these factors, and at the same time address the necessity for planned and reinforced instructional techniques which are delivered through systematic practice. These are measures that have been recommended to support the learning needs of students with HFASD (Armstrong & Hughes, 2012; Campbell, 2010; Lang, 2010; Williams, 2012). Unfortunately, many technology-based interventions for students with HFASD and new technologies such as the iPad, have focussed on the development of discrete academic skills, communication, and social and adaptive behaviours over more critical academic skills such as reading comprehension (Kagohara, 2012). Although Armstrong and Hughes (2012) utilised technology when examining the impact on reading comprehension with repeated story book readings for students with HFASD, the intervention was randomised. This meant that the students experienced repeated readings on the computer *and* face-to-face storybook making it difficult to determine which element best supported the positive outcomes shown by four of the five participants.

To address the difficulties with reading comprehension often demonstrated by students with HFASD, a focussed strategy-based approach using new technology such as the iPad could provide students with appropriate instructional techniques and opportunities for systematic practice and self-paced learning. However, evidence-based strategies shown to improve reading comprehension in students with HFASD would need to be embedded into the software and

delivered in a manner which supported the learner with 'appropriate' instructional techniques and practice. Considering the evidence-based strategies already discussed in this chapter, it was decided to evaluate the academic effectiveness of software applications (Apps) for iPad as a way to deliver systematic and practiced instruction that may resolve many of the social and emotional problems associated with traditional face-to-face instruction techniques in particular, reading comprehension.

This chapter has addressed the first aim of the present study which was to:

1. Synthesise research findings on reading comprehension difficulties for students with HFASD and identify the evidence-based strategies that can support improvements;

The following *Chapter 3* will answer the research sub-question:

> "What are the key criteria and design features to consider when creating educational software for mobile technologies?"

This will be achieved by addressing the following aims of the present study:

2. Determining the key issues and features associated with the design of quality educational software;
3. Embedding the evidence-based reading comprehension strategies identified in this chapter with the key features of quality educational software into an interactive 'App' format;

Chapter 3 - Design and Creation of the App Intervention

The literature review in *Chapter 2* examined the factors that influence reading comprehension and identified a number of evidence-based strategies that support reading comprehension for students with HFASD. This chapter will review the research concerning educational software design. Key themes that emerge from the literature will be examined regarding features that researchers have suggested are necessary for promoting learning. These themes are discussed and drawn together to explain the process of designing an App to support reading comprehension. This research establishes the principles underpinning the purposeful selection of key design elements of the App intervention created for this study. These have been synthesised with evidence-based strategies drawn from the literature review as embedded learning content in order to answer the research sub-question:

> "What are the key criteria and design features to consider when creating educational software for mobile technologies?"

3.1 Background

For some time researchers have highlighted the lack of evidence regarding the learning outcomes of using mobile technologies in the field of developmental disorders (King, Thomeczek, Voreis, & Scott, 2014; Knight et al., 2013; van der Meer et al., 2015). For example, Stephenson and Limbrick (2013) reviewed 36 research studies involving touch screen mobile devices and participants with developmental disabilities. This review concluded that few studies to date have focused on the development of academic skills with new mobile technology, and

that in these instances the evidence provided was mostly suggestive. King et al. (2014) explored the way in which children and young adults with ASD use iPads in the classroom stating, "the field would benefit from further research to address the question of whether [the] use of Apps improves learning" (p. 167). The aim of the present study fits within these and other recommendations concerning the use of mobile technology, academic gains, and students with ASD (Knight et al., 2013; Stephenson & Limbrick, 2013; van der Meer et al., 2015).

To undertake the present study, an App was required for use as the intervention tool. A review of the literature concerning software and design features that were considered desirable or necessary for mobile technologies revealed some inconsistencies which will be discussed throughout this chapter. The research process also conducted a review of available App products that were rated highly by practitioners as beneficial in supporting students' reading comprehension. It became evident that many currently available App products did not closely align with recent frameworks and recommendations for optimum educational App design and development. As a result, the key evidence-based features which emerged from the following literature were subsequently incorporated into the creation of the App intervention for this study.

3.2 Motivation and Engagement

Student motivation and engagement feature prominently in most contemporary instructional design models for learning (Martin & Ertzberger, 2013). This is relevant when considering the results from studies into iPad or tablet computing, as the majority reported higher levels of student engagement and motivation over traditional classroom instruction (Hutchison et al., 2012; Kucirkova, Messer, Sheehy, & Fernández-Panadero, 2013; O'Malley, Jenkins, Wesley,

Donehower, Rabuck, & Lewis, 2013; Pegrum, Oakley, & Faulkner, 2013). Motivation and engagement cannot, however, necessarily equate to increased academic gains (Arthanat, Curtin, & Kontak, 2013). New technology, such as iPads and tablet devices are considered desirable and socially acceptable and have display and communication attributes that are considered to be attractive and engaging to the users (Newton & Dell, 2011). Sheppard (2011) noted that while iPads and tablet devices have many popular features, the evidence concerning their effectiveness in schools is not yet established. In a study of mainstream primary school education students reading eBooks on iPads as opposed to traditional texts, Sheppard (2011) indicated that despite an increase in students' engagement when using the iPad, there was little corresponding rise in students' achievements. Similarly, when examining levels of students' engagement between traditional computer aided instruction and new mobile technology, Arthanat et al. (2013) reported few distinguishing trends between interactions with either device in primary school aged children with developmental disabilities. In a related study, Armstrong and Hughes (2012) compared gains in reading comprehension levels between traditional texts and e-books for five primary school aged students diagnosed with HFASD. Results indicated comprehension gains across both treatment conditions with little significant differences between either. That is, it appeared that traditional texts and e-books were just as effective in assisting students enhance their reading comprehension. These results indicate it is too simplistic to think that the form in which the text is presented to the reader is the one critical feature in improving students' reading comprehension. Teacher effects, the design, quality, and suitability of the resources, as well as student and family variables, all can influence students' learning (Hattie, 2013). For example, Hedman and Gimpel (2010) noted that although motivation and engagement are important, other variables that support students' learning need to be embedded with the software design. These

include elements such as scaffolding students' learning, providing opportunities for students to review and develop their skills, and ensuring that the technology is linked to meaningful academic tasks (Hedman & Gimpel, 2010). They suggest that these elements have a greater impact on learning outcomes in combination with the mode of delivery.

3.2.1 Gaming

The integration of computer learning games into the classroom has become an extensive field of research in recent years, as many children spend several hours per week engaged in digital gaming either at home or at school (Su & Draper Rodriguez, 2012). In many ways 'gaming' has become a popular way to engage students in learning (Prensky, 2001). This trend has been the focus of many software developers which is relevant when considering the ever increasing number of 'educational Apps' available for mobile devices purchased by parents and educators. Developers have acquired the capacity to generate a large number of Apps from a single design framework often using a simple change in content (Murray & Olcese, 2011). These game engine templates have allowed for rapid construction of gaming Apps, thus reducing the time and cost associated with development. As a result, this genre of game Apps can deploy the same game across different mobile platforms relatively cheaply and is a contributing factor to the proliferation of game based Apps across personal and educational contexts (Masek, Murcia, & Morrison, 2012). The functionality of this software can be basic, such as allowing the user to practice appropriate questions for exams or do counting, numeracy tasks, and spelling games (More & Travers, 2012; Murray & Olcese, 2011).

Despite most research demonstrating that digital learning games are an effective means to motivate many learners (Gee, 2003; O'Malley et al., 2013; Papastergious, 2009; Van Eck, 2006), many researchers continue to raise concerns regarding their actual learning benefits (Erhel & Jamet, 2013; Su & Draper Rodriguez, 2012). Some researchers highlight that students may be focusing primarily on the game content of an App instead of the less explicit learning tasks embedded within the game (Erhel & Jamet, 2013; Lynch & Redpath, 2012; Tsai, Yu, & Hsiao, 2012). Su and Draper Rodriguez (2012) examined the difference in gaming features across two separate studies with mainstream pre-school children in the curriculum areas of literacy and mathematics. In terms of students' learning, they concluded that the more entertaining and engaging learning games reported less academic growth than the least engaging learning games. These findings were similar to a mainstream early childhood classroom study utilising 45 different educational Apps for iPad (Falloon, 2013). The Apps used in this study were either downloaded free or purchased from iTunes, with content ranging from basic problem solving skills to focused curriculum areas. Falloon noted in many instances the absence of appropriate parameters within educational Apps to guide and maintain a focus on learning. As a result, students would deliberately play and manipulate characters and App content to elicit amusing feedback such as sounds and responses, as opposed to staying on track with learning tasks.

3.2.2 Localisation

As contemporary pedagogy recognises the theory that knowledge can be socially constructed (Vygotsky, 1997), some researchers have argued it is also important to examine the socio-cultural features of available software (Draper Rodriguez & Cumming, 2012; Falloon,

2013). For example, an App created by a developer in the United States, with a standard USA curriculum focus, will often contain language, curriculum, and cultural concepts designed for middle class and 'average' students that may not be relevant for students in other countries or contexts. When discussing issues of localisation in educational software, Nikolopoulou (2007) argued for the need for adaptation of software content so that it meets the technical requirements of users and is relevant within the individual student's cultural, social, and learning contexts. This may involve changes in semantics, syntax, graphic representations, or ensuring that narration is in a standard accented-human voice (Churchill, 2011; Falloon, 2013). Although some software will contain content that may be considered neutral or even universal, such as developmental activities involving sorting and classifying, research suggests that to be effective, such software must still be delivered in a pedagogically appropriate manner that is aligned with specific curriculum outcomes (Edyburn, 2003; Haugland, 2005; More & Travers, 2012; Nikolopoulou, 2007).

3.2.3 Evaluative Frameworks

In an effort to effectively evaluate mobile technologies as a learning tool, researchers have used different frameworks to organise and categorise the hardware and software features of these new devices. Not long after the release of the iPad in 2010, Murray and Olcese (2011) considered 56 Apps classified by Apple as 'educational.' They applied the categories offered by Means (1994) to evaluate educational technology and allocated the Apps to different categories contingent on their content. These four categories consisted of: tutor; explore; tool; and communicate. Means described technology as: 'tutor' for drill or practice; 'explore' where

students assess information they access and make decisions regarding its use; a 'tool' for functional use such as word processing; and to 'communicate' with the exchange of information. Murray and Olcese (2011) included an additional fifth category of 'collaboration' to reflect the theory that knowledge is socially constructed. After evaluating the 56 chosen Apps classified as 'educational,' most were classified under Means' 'tutor' category. These Apps were mainly designed for individual users, and were mostly identified as having content designed from behavioural models of teaching (stimulus – response), and not necessarily designed for creation and collaboration (open-ended). Murray and Olcese (2011) concluded that much of the software categorised as educational did not maximise the hardware capabilities developed for the iPad device. These hardware features can increase access to educational materials through augmented visual imagery and voice over functions to enhance the presentation of educational concepts.

Su and Draper Rodriguez (2012) presented a framework developed from previous research into computer learning games to assist teachers in evaluating the suitability of software for learning purposes. The ten features that were considered as important were: (1) scaffolding; (2) collaborative interaction patterns to increase engagement; (3) highly digitized speech and colourful graphic images; (4) interactive tasks requiring an active response; (5) clear instructions; (6) opportunities to practice tasks; (7) consistent intervals of time for each learning task; (8) encouragement, reinforcement, and modelling; (9) feedback to correct and incorrect responses; and (10) age appropriateness of both content and how it is presented. Su and Draper Rodriguez also recommended that future iPad developers should also aim to: incorporate a suitable blend of learning, practice, and game elements; create student pathways to learning goals that were free from distraction; and design software features that ideally can replicate the pedagogy of the

classroom teacher. Similarly, in the evaluation of a range of educational Apps for children in early learning environments, Falloon (2013) identified similar features to the Su and Draper Rodriguez framework. Falloon noted that these design features should "promote thoughtful engagement and productive learning" (p. 519). Nikolopoulou (2007) also recommended that "software be integrated into the classroom with appropriate pedagogic approaches" (p. 178). Reporting on Apps that had application for students receiving some level of special education, More and Travers (2012) and Newton and Dell (2011) argued that best practice should determine that App selection be matched to Individual Education Plan goals. As a result, it would be beneficial to require software categorised as educational to demonstrate clear curriculum connections which could better assist teachers faced with an ever constant flood of available educational Apps (More & Travers, 2012).

One of the most comprehensive studies concerning the evaluation of Apps for educational purposes was conducted by Walker (2014). This study was designed to establish appropriate content or domain criteria as a tool to evaluate Apps (see Appendix C). Walker's seven domain criteria were developed in consultation and collaboration with more than 90 educators from several countries who, through an iterative process, provided feedback on each rubric domain and subsequent rating descriptors. Each domain was rated by participants based on content validity (Lawshe, 1975). Walker's seven domain criteria are listed below.

1. Curriculum Connection, and how well the targeted skill or concept is directly taught through the App.
2. Authenticity, where targeted skills are practiced in an authentic format/problem-based learning environment.

3. Feedback that is specific resulting in improved performance and data that is available electronically to student and/or teacher.
4. Differentiation, where the App offers complete flexibility to alter settings to meet students' needs.
5. User Friendliness, where students can launch and navigate within the App independently.
6. Motivation, how highly students are motivated to use the App.
7. Student Performance, where students show outstanding improvements in performance as a result of using the App.

The domain criteria listed above can assist educators in selecting and evaluating appropriate educational Apps, the manner in which classroom resources such as an App is used in an educational context is still the responsibility of the teacher (Hattie, 2013). Even as these domains are similar to other evaluative frameworks, the manner in which an App delivers learning content is in many cases implicit. Often, little emphasis is placed upon the pedagogical approaches within the software's function and design that will facilitate a student's understandings. When examining software that is classified as 'educational,' what is often evident is a focus on *content* rather than *process,* and a distinct lack of appropriate 'pedagogical content' embedded within the function and design of educational software (Falloon, 2013). A focus on 'thinking' is more related to the pedagogical purpose of the software. This differentiation between content knowledge and pedagogical content knowledge has been investigated by Shulman (1986). Shulman argued that teachers need knowledge of the strategies most likely to be fruitful and effective in reorganising the learning process for the individual

student. In the same way, this argument could be applied to Apps or any educational technology. This perspective does not mean that the software replaces the teacher's role, but provides relevant support that is underpinned by appropriate pedagogical principles in order to augment a student's learning (Nikolopoulou, 2007). For educators and software developers this means being aware of the specific pedagogical content knowledge they would apply across a curriculum area and see this transposed within software function and design. Shulman (1987) considered that pedagogical content knowledge:

> "…identifies the distinctive bodies of knowledge for teaching. It represents the blending of content and pedagogy into and understanding of how topics, problems, or issues are organized, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction. Pedagogical content knowledge is the category most likely to distinguish the understanding of the content specialist from that of the pedagogue [the general teacher]." (Shulman, 1987, p.8).

By drawing together the key elements of Walker's (2014) and Su and Draper Rodriguez's (2012) evaluative frameworks and applying an appropriate pedagogical model for delivery, the hope is that more effective learning tools can be created, particularly for students with HFASD.

3.3 Apps Evaluated for Reading Comprehension

Several Apps were reviewed using on the frameworks and recommendations previously in this chapter. The Apps were initially evaluated using the Walker (2014) framework determined by the inclusion of functions and the level of functionality of key features (see

Appendix C). To augment the evaluation process, the ten features Su and Draper Rodriguez (2012) described as important features of mobile learning games were used as additional descriptors and to guide the evaluative process of determining how well each App met the domain criteria on the Walker framework. A summary of these Apps is provided below, with respective numerical ratings taken from the domain criteria set out by Walker (2014). Each domain has been rated from 1 to 4, the latter as representative of most closely meeting the each domain's highest purpose (see Appendix C). The 11 Apps reviewed were selected from online web sites specialising in educational Apps for typical students and those with developmental disabilities. These Apps were all described as being rated 'highly' by their independent reviewers. The keywords used for the search were 'reading comprehension Apps' and 'Autism and reading comprehension Apps'. The sites selected were; The Learning App Guide (Bronwyn Sutton Speech Pathology, 2013), te@ch thought (te@ch thought, 2015), Commonsense Media (Common Sense Media, 2015), Best Apps for Kids (Best Apps for Kids, 2013), Speech Therapy for Autism (Speech Therapy for Autism, 2012).

Table 3.1

Reviewed Apps for reading comprehension using the Walker (2014) criteria

Key Word Kids - (Language And Learning Steps Pty Ltd., Updated 2014)		
Learning Connection	Focus on language learning and key words	3
Authenticity	Australian content, game setting	3
Feedback	Prompt guides a correct response – emailed data	3
Differentiation	Option of voice and/or text	2
User Friendliness	Would require some assistance in navigating	3
Motivation	Game content	3
Student Performance	Reporting	4
Aesop's Quest - (NRCC Games., 2011)		
Learning Connection	Focus on inferences and comprehension	3
Authenticity	Game focus with accrued points, reliance on memory recall	2
Feedback	Basic correct or incorrect responses	2
Differentiation	No supporting visuals, text only, increasing levels of difficulty	1
User Friendliness	Easy to use independently	3
Motivation	Strong focus on game elements, students could lose motivation by having to go back and re-read story if too many incorrect responses	2
Student Performance	No reporting	0

Fun with Directions HD - (Hamaguchi Apps for Speech, Updated 2013)

Learning Connection	Focus on verbal and language comprehension, concept based	3
Authenticity	Reliant on memory and recall	2
Feedback	No feedback if incorrect	2
Differentiation	Good selection of concepts	4
User Friendliness	Easy to use independently	3
Motivation	Repetitive	2
Student Performance	No reporting	0

Reading Comprehension Camp - (Smarty Ears., Updated 2014)

Learning Connection	Reading and auditory comprehension	4
Authenticity	Work within text, American language, text too short	2
Feedback	Easy for student to select hint without attempting answer	2
Differentiation	Well differentiated, font, answer choice	4
User Friendliness	Adult supervision required to select appropriate levels	2
Motivation	Good visuals	3
Student Performance	Reporting on each task	4

Languages Adventure Quizz Show GR 4-6 - (Lakeshore Learning Materials., Updated 2014)

Learning Connection	Focus on language, little on comprehension	3
Authenticity	American language and content, gaming	3
Feedback	Tick and Cross with earned points	2
Differentiation	Option of voice and text	2
User Friendliness	Easy for students to use independently	4
Motivation	Game show format	2
Student Performance	No Reporting	0

Reading Comprehension Solar System Free for 5th Grade - (Abitalk Incorporated., Updated 2014)

Learning Connection	No reading comprehension strategies, reliant on memory	1
Authenticity	American language, matching activities for vocabulary knowledge	2
Feedback	Sounds for correct/incorrect response. Report on responses	2
Differentiation	Create own stories, add pictures and text	4
User Friendliness	Easy for students to use	3
Motivation	Can adapt to suit student interests	3
Student Performance	Reporting *In app purchases and advertising	4

Reading Comprehension First, Second Grade Non-fiction - (Chen, Updated 2014)

Learning Connection	No reading comprehension strategies, reliant on memory	1
Authenticity	American language, matching activities for vocabulary knowledge	2
Feedback	Sounds for correct/incorrect response. Report on responses	2
Differentiation	Create own stories, add pictures and text	4
User Friendliness	Very easy for students to use	4
Motivation	Can adapt to suit student interests	3
Student Performance	Reporting *In app purchases	4

WH Expert2 Reading Comprehension Skills for Struggling Readers - (Toole, Updated 2015b)

Learning Connection	Reading comprehension	3
Authenticity	Focus on phrases, relies on memory recall	2
Feedback	Correct/incorrect responses, no hints or scaffolding	1
Differentiation	Sounds and music can be turned on or off, no audio	1
User Friendliness	Students need to be able to read	2
Motivation	Game format	3
Student Performance	No Reporting	0

Kids Reading Comprehension Level 2 Passages for iPad - (Reed, Updated 2014)

Learning Connection	Few comprehension strategies, no higher order skill development	2
Authenticity	Short stories with accompanying pictures	2
Feedback	Correct/Incorrect responses, no hints or scaffolding	1
Differentiation	Fixed settings	1
User Friendliness	Very easy for students to navigate and use	4
Motivation	Student receives positive response at end of story	2
Student Performance	Progress reports	4

Language Empires - (Smarty Ears., Updated 2015)

Learning Connection	Focus on defining meaning and language forms	3
Authenticity	Reliant on memory recall	2
Feedback	Correct/Incorrect responses, no hints or scaffolding, report	2
Differentiation	Levels of difficulty, option of voice and text	3
User Friendliness	Students need to be able to read	3
Motivation	Great visuals, thematically different, gaming	3
Student Performance	Reporting	4

Inference Clues: Reading Comprehension Skills - (Toole, Updated 2015a)

Learning Connection	A good focus on inference instruction only	3
Authenticity	American language and content	2
Feedback	Correct/Incorrect responses, no hints or scaffolding	2
Differentiation	Music and sound can be turned on or off	1
User Friendliness	Easy to navigate	3
Motivation	Very repetitive	1
Student Performance	Some reporting	3

3.4 The Evaluation Process

The Apps chosen for this review were rated as 'highly recommended' by independent reviewers. Most of these Apps met the inclusion criteria for each of the Walker (2014) domains at some level. One of the issues that became apparent through this process was in determining the choice of online web site. The online sites chosen specialised in educational Apps for typical students and those with developmental disabilities and it is likely that teachers and parents would face similar considerations when selecting educational software. Additionally, it is difficult to determine the qualifications of the personal that review the App products. These problems were overcome to some degree as the Apps evaluated in the present study were in the 'highly' rated category across all four online sites.

The Apps were individually evaluated by the researcher who reviewed each feature and function of the software against the domains of the Walker (2014) framework. As previously mentioned, consideration was also given to recommended features described by Su and Draper Rodriguez (2012). A common feature that was not incorporated by some of the evaluated Apps was a reporting function. Reporting functions provide a means for teachers or parents to monitor progress and/or improvements in learning. For the purpose of the present study, reporting functions were categorised under the 'Student Performance' domain and not evaluated against the Walker framework as 'Feedback'. As a result, the 'Feedback' category was interpreted by the way in which the software responded to the reader's correct or incorrect results, and to what degree if any, the software supported the student's learning by provision of hints or clues (Sue & Draper Rodriguez, 2012). For example, each time a reader chose an incorrect answer to a question, the software removed that answer from the initial selection. In effect, the reader would eventually choose the correct response through a process of attrition. Therefore, the absence of guidance or scaffolding in the form of hints and clues would mean a low rating in the 'Feedback' domain. Other examples include Apps with an audio function for reading purposes that could be turned on or off. This function was evaluated against the 'Differentiation' domain. The Apps with an audio function in addition to providing levels and grades of difficulty were considered to deliver a higher degree of differentiation. These Apps received a higher rating in the 'Differentiation' domain than those with an audio function only. The process of evaluating of different App products was useful in determining the functionality and software inclusions for the App product developed as the intervention for the present study (Somerton, 2014).

3.5 The App

It was important that the App software designed and developed for this study was as closely aligned with key considerations arising from evidence-based reading comprehension strategies and recommendations for pedagogical software design. The software design was underpinned by the broader frameworks suggested by Su and Draper Rodriguez (2012) and Walker (2014), and the embedded teaching strategies were drawn from research discussed in the literature review (see *Chapter 2*). The strategies were those that had been consistently applied within several studies and were had demonstrated improvements performance for some students with HFASD (Whalon et al., 2009).

The App was created from a children's story published in 1914 (Burgess, 1914). The story was available within the public domain, therefore negating any issues with copyright. The App 'Billy Possum's Interactive Comprehension' was created from the text of 'The Adventures of Unc' Billy Possum' and was purposefully chosen by the researcher as it was a chapter story. The original text and the purposefully created digital version in the present study consist of more than 15000 words of text and embedded strategies. The structure and length of a chapter story provides the student with multiple opportunities to practice higher order comprehension skills, in this instance, over the course of the 25 chapter text. Alternative educational Apps typically offered short paragraph style, or factually based stories that were unrelated in content. This short story format could make it difficult for many students to develop appropriate 'schema' and the appropriate cognitive networks that a longer narrative can provide. The importance of this was raised by O'Connor and Klein (2004) and Woolley (2011) who explained that the development of 'schema' associated with a story allows the reader to reflect on what has already happened within the story and predict what is likely to happen next. This also allows the reader to explore the

characters and the plot which is important for establishing context and developing understandings when accessing and integrating information through text Woolley (2011). Of importance for students with HFASD, the development of the reader's cognitive schema associated with an extended piece of text allows the reader to explore the social relationships between the characters and the emotions of the characters. Students with ASD and HFASD are noted to have difficulties in interpreting people's feelings, emotions, and actions (Klin et al., 2000; Lord et al., 2000). The opportunity for students with HFASD to explore, reflect, and review the personalities, emotions, behaviours and actions of the characters in a 'safe setting' such as story, was an important consideration in the selection of the narrative used in the present research study.

As the selected text 'The Adventures of Unc' Billy Possum' was first published in the United States, a review by the researcher found that much of the language was not suitable for contemporary Australian student readers. In addition, there were several animal characters indigenous only to an American context. Accordingly, the story and some of the characters were modified (see Appendix D) to create a context that was culturally relevant, interesting, and motivating (Nikolopoulou, 2007) for the participants in the present study who were recruited in Australia.

To ensure that the vocabulary and the complexity of the text and sentences were age appropriate for the intended participants (Su & Draper Rodriguez, 2012), the modified text was subsequently analysed using Fry's Readability Scale (Fry, 1968). This identified parts of the text ranged from a reading age of around 8 – 11 years of age, with much of the text suitable for a reader in middle primary school. The aim was not to select a text that was too easy or simple

which would not challenge the readers, nor select a text that was too advanced or difficult that would frustrate the readers. The aim was to select a text that would be at an instructional level as per the reading levels proposed by Holdaway (1972) and McNaughton, Glynn, and Robinson (1981). When the text is read easily by the student with few to no errors it can be said to be at an 'independent' level. If the reader has real difficulties and makes frequent errors, the text can be described as being at 'frustration' level. The optimum level for the reader is seen as 'instructional' where comprehension of the text can be measured at around 80%. For the majority of participants, the selected text provides opportunities at 'instructional' level to advance their reading and comprehension, well supported by the embedded strategies and scaffolding of the software (Duke & Pearson, 2002; Woolley, 2011).

The App was designed to be a tool for self-directed learning and independent practice for the participants in the present study (Flores et al., 2013; Ganz & Flores, 2009), therefore it was important to consider how the software could be designed to scaffold this process through a pedagogical approach similar to that of a teacher (Falloon, 2013; Su & Draper Rodriguez, 2012). Once the App is downloaded, the reader chooses their own character (see *Figure 3-1*) but cannot proceed to unlock any of the story chapters until the instructional 'walkthrough' has been completed (see *Figure 3-2*). This is to ensure that the reader has an opportunity to learn how to use and navigate their way through the App independently (Walker, 2014).

Figure 3-1 Add user screen in App with choice of six avatars

Figure 3-2 Screen shot of Chapter view in App showing Walkthrough and Chapter 1 completed

In consideration of previous research on scaffolded learning which has also demonstrated the effectiveness of providing prompts (Whalon & Hanline, 2008), the software was designed with a focus on interactive tasks that require active responses (Su & Draper Rodriguez, 2012). Throughout the story, and embedded within each chapter, are strategies to support reading comprehension (see Appendix E). These strategies include the dictionary function (see *Figure 3-3)* which provides meanings of more difficult words to support vocabulary, and comprehension tasks presented in 'cloze' format consistent with the research conducted by O'Connor and Klein (2004) and Bellon et al. (2000).

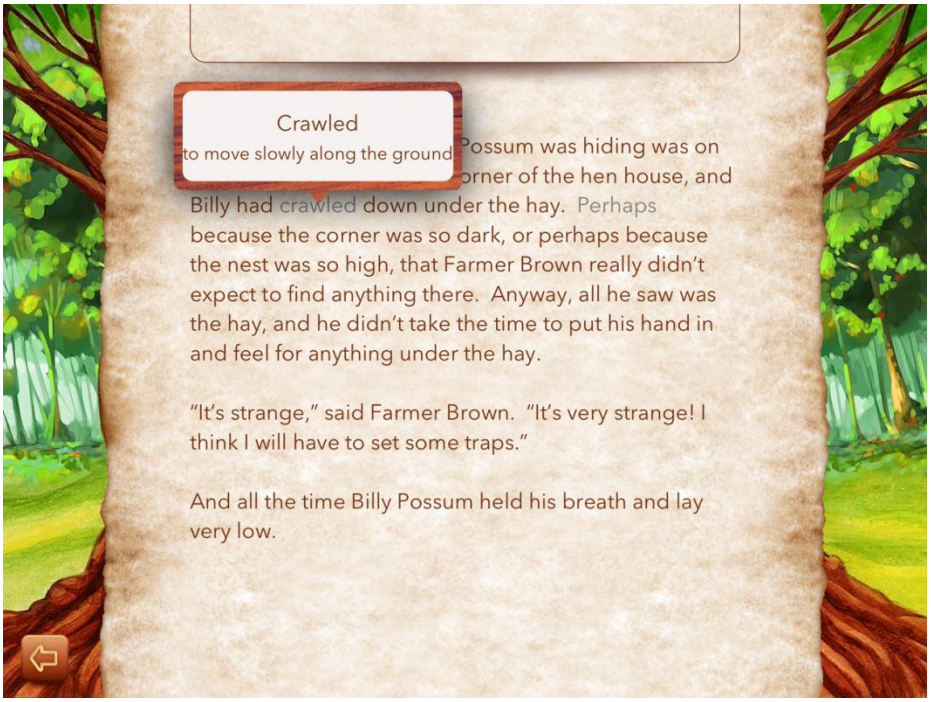

Figure 3-3 Screen shot in App of text with dictionary function displayed

Cloze is an instruction format where some vocabulary is missing in a sentence, and the reader must insert or select the word that best fits that sentence, yet still maintaining the schema or comprehension of the whole passage (Duke & Pearson, 2002). It is important to acknowledge that the way in which the comprehension strategies are embedded in the story do not take the student 'out' of working within the text to answer questions, thereby following a known pedagogical approach (Edyburn, 2003; Falloon, 2013; More & Travers, 2012; Nikolopoulou, 2007; Shulman, 1986). In this way the 'authenticity' of the learning task is retained in the same way as when they would be reading a traditional text, and there are clear curriculum connections (Su & Draper Rodriguez, 2012; Walker, 2014). The comprehension strategies embedded within the App include: anaphoric cuing (Campbell, 2010; O'Connor & Klein, 2004), sequencing ideas or events, character feelings and emotions, making predictions (Earles-Vollrath, Cook, Robins, & Ben-Arieh, 2008; Whalon & Hanline, 2008; Whalon & Hart, 2010), and visual picture building (Bell & Bonetti, 2006; Carberry, 2014; Van Meter et al., 2006). The strategies require the reader to work with a literal comprehension of the words and passage, as well as inferential comprehension, and require the reader to link different pieces of information within the text together to choose an appropriate response (Flores & Ganz, 2007; Flores et al., 2013; Whalon & Hart, 2010).

Table 3.2

Examples of the strategies and 'cloze' comprehension activities embedded in the App

Type	Example 1	Example 2	Example 3
Anaphor	# saw Peter Rabbit whispering a secret.	# was very, very hungry.	It was # who made up his mind to stay.
Literal	It was # that came up with a good idea.	Inside the hollow log it was #.	Mrs Possum had # babies.
Inference	Billy Possum was feeling #.	Mrs Possum was worried because #.	Prickly Pork was unhappy because he thought #
Sequence	Reddy gets a fright Reddy thinks Billy is dead Reddy goes to Billy's tree	Billy Possum's family arrive Prickly Porky sat on the log Reddy was trapped	Billy was sleepy Billy followed the track Billy ate lots of eggs

After completing the instructional 'walkthrough' the reader receives a 'key' to unlock the first chapter of the story. A passage of text is released with a 'strategy' icon at the bottom of the passage (see *Figure 3-4*). The student reads and/or listens to the text and is unable to proceed further into the text until the strategy is completed with the correct response. If the first response to the strategy is incorrect, a hint or clue in the form of a prompt is provided. The prompt highlights parts of the preceding text that supports a correct answer (see *Figure 3-5*). If the second response is also incorrect, then the software shows the student the correct answer (see *Figure 3-6*). This is, in part, mirroring the same way in which a teacher would provide prompts and scaffolding as part of direct instruction techniques in face-to-face teaching instruction (Armstrong & Hughes, 2012; Whalon & Hanline, 2008). Therefore, the student is receiving

appropriate and immediate feedback to correct and incorrect responses (Su & Draper Rodriguez, 2012; Walker, 2014). Teachers or parents can monitor the reader's level of correct and incorrect responses through an electronic spreadsheet in report format (Walker, 2014). This spreadsheet information can also be used as a diagnostic tool as it reports directly on student performance, error rates, and hints. This form of monitoring shows which particular task, or area of reading comprehension the reader may be having difficulty with, so a more individualised program could be designed for the student.

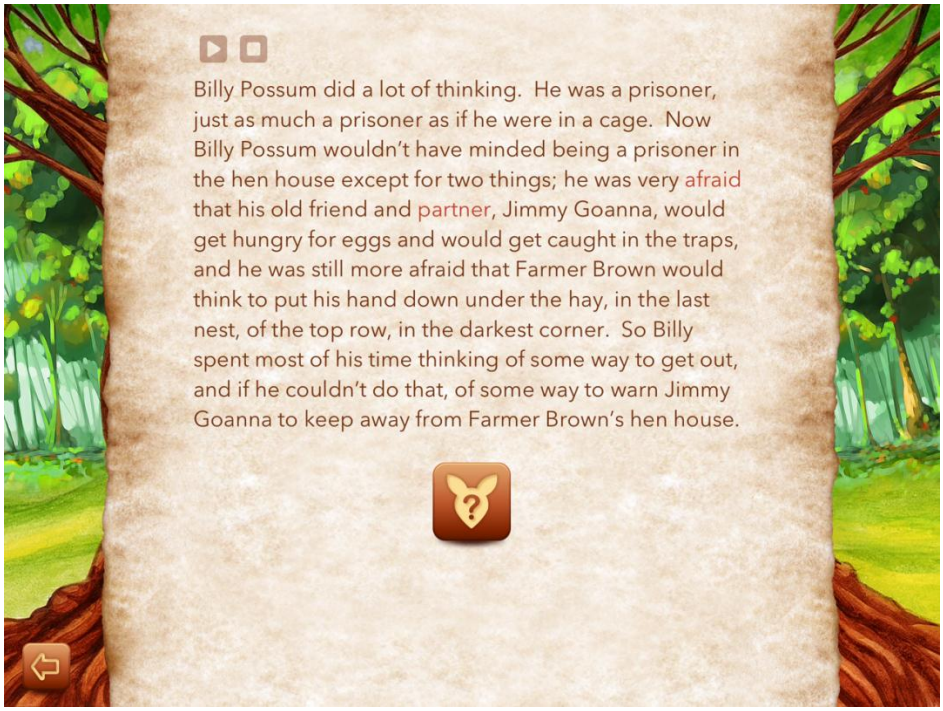

Figure 3-4 Screen shot in App of text with question prompt

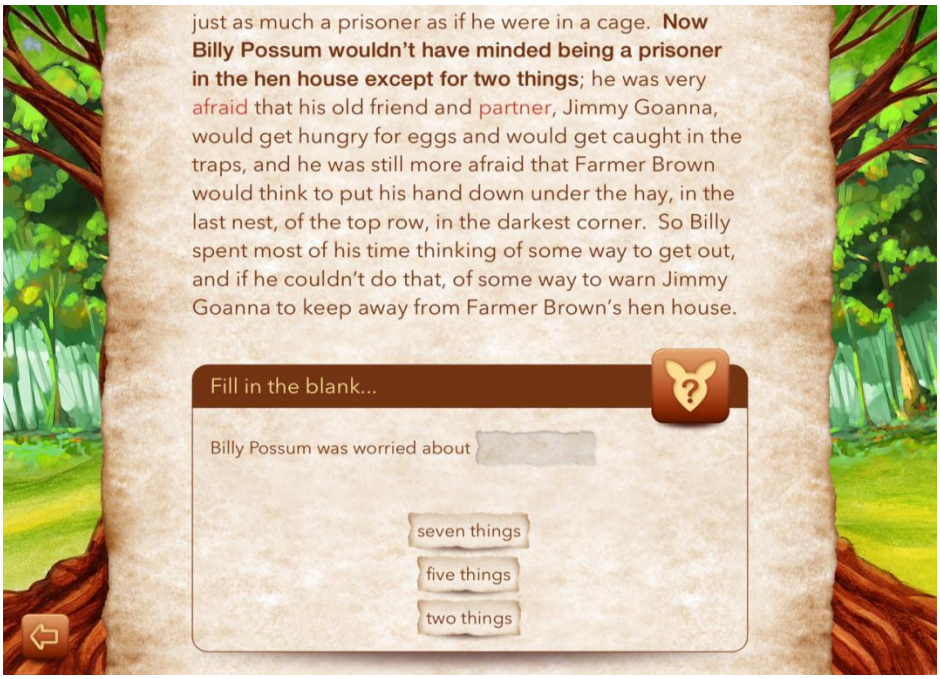

Figure 3-5 Screen shot in App after incorrect response and highlighted text to scaffold second response

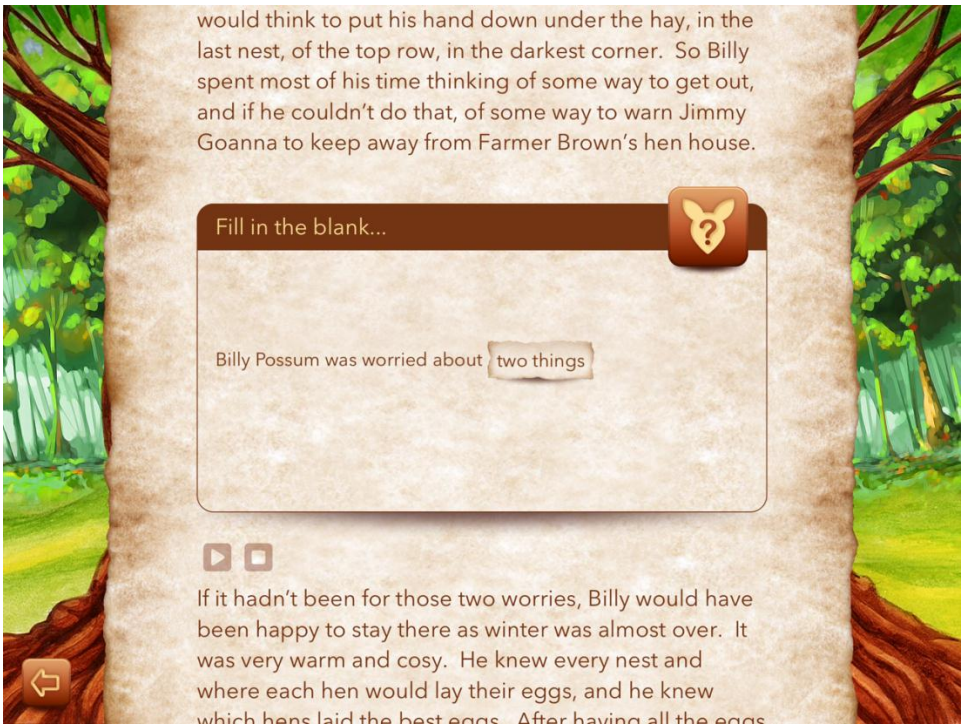

Figure 3-6 Screen shot in App of correct response and release of following text

Providing access to the text for different learning styles was also a consideration (Walker, 2014). Even as some individuals with HFASD may demonstrate a visual processing bias, there are still other students for which the provision of auditory information may be preferential (Roth et al., 2012). The incorporation of an audio option into the text in a standard accented human voice (Churchill, 2011; Falloon, 2013) can support an individual's processing preference (Kunda & Goel, 2011), assist readers who are less fluent, and link text with the paralinguistic aspects of pragmatic language such as prosody or pitch, tone, and modulation (Grynszpan et al., 2008). This linking of the text to the spoken word supports the reader's processing of the words and assists the reader to mirror the style and pace of the spoken voice they are listening to when reading along with the text (Grynszpan et al., 2008). The audio option can be turned on or off at any point throughout the story.

To further assist the development of comprehension using a visual mode to assist those students with HFASD with a visual 'bias' (Knight et al., 2014; Kunda & Goel, 2011), the App offers readers with the opportunity to create rich graphic representations of the text through a 'picture builder' option (Su & Draper Rodriguez, 2012). The graphic representations are 'traditionally' represented and consist of several painted scenes and characters drawn from the text (see *Figure 3-7*). These pictures were hand drawn, painted, and digitalised. The use of rich, strong and contrasting colours used in this format is in contrast to the Apps reviewed earlier in this chapter. Hurlbert, Loveridge, Ling, Kourkoulou, and Leekam (2011) found that colour discrimination can be reduced in individuals with ASD, mostly in an ability to discern light and saturation. The images within the Apps that were evaluated in this chapter were often pale and in muted colours. In the majority of evaluated Apps, images were of a digital 'cartoon genre' and

the typical features of people, places, or animals were not represented in an authentic or natural in manner. As previously mentioned in *Chapter 2,* Glenberg and Langston (1992) explained that 'good' illustrations are able to assist less experienced readers in providing information that is not directly or explicitly written into text.

Figure 3-7 Screen shot in App of picture builder

Rather than provide the reader with a completed visual representation of the text or take considerable time out from the read text to draw a picture, the 'picture builder' provides the reader with opportunities to construct their own visual understandings (see *Figure 3-7* & *3-8*). These were explained by Van Meter et al., (2006) as important in supporting the organisation of

textual information. The reader is able to select specific story elements at different stages within the text, to construct new visual and mental representations of the text and integrate these images with their existing knowledge or schema. These visual images when completed are stored within the body of the text in the App. In this way the reader can revisit and re-read the text and their visual representations at any point in the reading process, reinforcing their organisation of information (Bauminger-Zviely, 2013; Van Meter et al., 2006). The use of visual and audio scaffolding provided by the software, together with the opportunity for consistent and independent practice, has been found to support the development of students' reading comprehension which, in turn, supports these comprehension processes in becoming more automatic (Woolley, 2010).

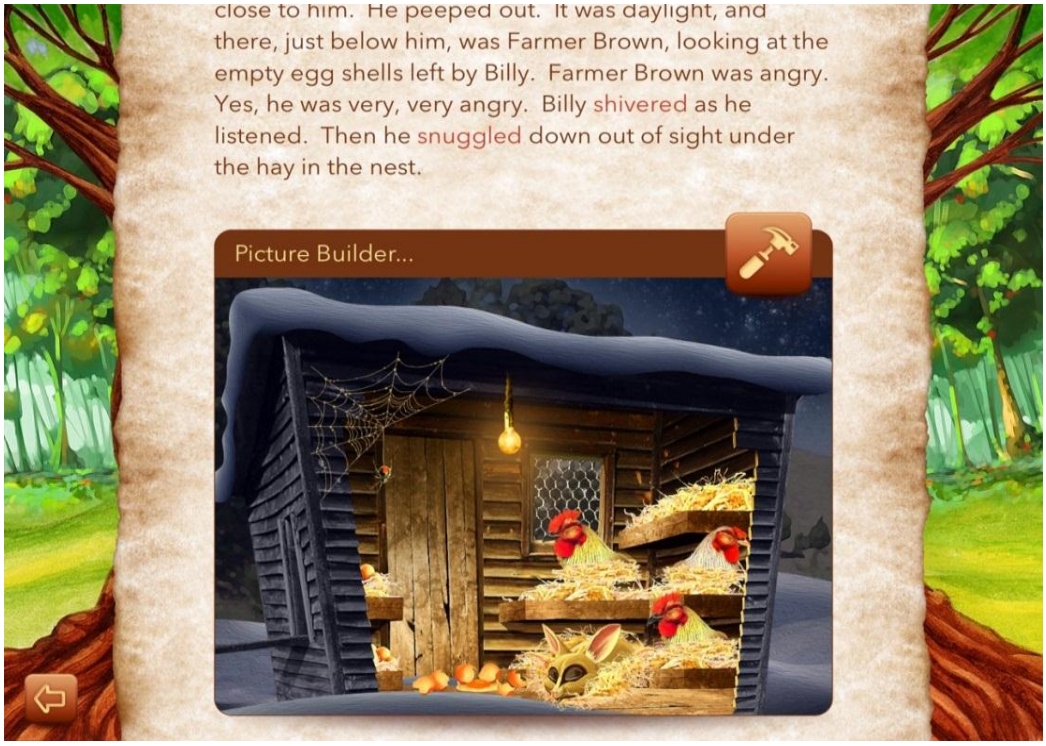

Figure 3-8 Screen shot in App of picture builder completed by student

3.6 Summary

Acknowledgement is made to 41st Degree Software (2015) for the technical assistance and illustrations they supplied as part of creating of the App intervention.

This chapter has reviewed the key principles and themes associated with computer-assisted learning and synthesised these with the evidence-based reading comprehension strategies for students with HFASD reviewed in *Chapter 2*. Despite some inconsistencies in the literature, an explanation and justification for the design of the App employed as the intervention instrument in the present study has been provided. The processes described and in this chapter are represented in the aims of the study as:

2. Determine the key issues and features associated with the design of quality educational software;
3. Embed the evidence-based reading comprehension strategies identified in this chapter with the key features of quality educational software into an interactive 'App' format.

The following explains the methodology, method, and procedure applied to the intervention. *Chapter 4* will provide the justifications for the design of the present study through the research literature, with a focus on the field of special education research.

Chapter 4 - General Methodology

4.1 Methodology

Methodologies in research are processes, or ways of knowing, and can draw on a number of empirical (observation and experiment) and non-empirical (theory or personal experience) sources of evidence (Kervin, Vialle, Herrington, & Okely, 2006). Different questions may require a range of methodologies in order to provide answers, however, within the field of educational research there has been concern and disagreement regarding the type of data that can be considered quality or acceptable evidence (White & Smith, 2002).

Educational research, including research focusing on students with special education needs, is important as the foundation for the development of effective practice but this research faces many challenges. One of the challenges in conducting and reporting special education research is the diversity of diagnoses, and the heterogeneous nature of many disabilities and impairments, and how these different levels of impairments impact upon individuals (Odom, Brantlinger, Gersten, Horner, Thompson, & Harris, 2005). An implication which arises from these complexities at the individual, classroom, family, and even at the community level, is the need to try to better identify for whom a particular strategy or program is effective, and within what context (Guralnick, 1999; Rose & Grosvenor, 2013). This often requires research work in real educational settings where the researcher is less able to control the variables that directly or indirectly influence the students' performance on an intervention (Rose & Grosvenor, 2013; White & Smith, 2002). Odom et al. (2005) defined 'high quality' research in terms of the extent to which it is designed to negate alternative explanations for either results or conclusions. Thus, high quality research requires a relevant methodological approach to address a question or

problem, in addition to high levels of rigor in method. These factors in tandem can justify more confidence in the findings of a study.

In recent reviews of educational research, professional and governmental organisations such as the Council for Exceptional Children (CEC), Institute for Educational Studies (IEC), and National Research Council (NRC), have acknowledged that different methodologies are important for specific questions (Odom et al., 2005), and charged divisional research committees within these organisations to synthesise research methodology to define 'high quality' research methods. A report on research in education from the National Research Council (2002) noted that scientific methods used in other fields such as medicine also needed to be applied in education. They emphasised that research involving experiments using comparison trials is one indicator of high-quality group design research. Rose and Grosvenor (2013), in their review of special education research, argued that there is no one method, but rather a range of methodologies that have application in investigating supports for students and individuals with additional needs.

In an attempt to develop guidelines for reviewing and conducting experimental research in education, Gersten et al. (2005) described specific quality indicators as either desirable or essential. These quality indicators address points regarding conceptualisation, validity and fidelity, replication, and discuss other issues such as generalisation, comparability, and reliability. In a similar way, the CEC Division for Early Childhood have defined standards and protocols for recommended research practices using single-subject, group, and qualitative research methodologies (Smith, Strain, Snyder, Sandall, McLean, Broudy-Ramsey, & Carl-Sumi, 2002). These recommended practices were used to evaluate studies determining quality research

methods in education such as reviewing single subject designs in research (Horner et al., 2005), and to inform the development of frameworks and guidelines for evidence based practice such as the National Autism Center's National Standards report (Luiselli, Russo, Christian, & Wilczynski, 2008).

The National Standards report (National Autism Center, 2009) reviewed the need for evidence-based research practice guidelines involving individuals with autism spectrum disorders and its authors argued for a scientific merit rating scale (SMRS). Such a scale could be used to objectively evaluate the design and methods used in a range of studies on interventions for individuals with autism. This framework provides a guide for reviewers and researchers and incorporates five critical dimensions measuring research rigor. These criteria are: (1) research design; (2) measurement of the dependent variable; (3) measurements of the independent variable or procedural fidelity; (4) participant ascertainment; and (5) generalisation of findings. The SMRS uses a rating scale from levels 1 to 5 and provides a description of the requirements needed to attain each specific level.

The present study designed an App to assist the development of reading comprehension for students with HFASD, and the research design was guided by the quality indicators for intervention studies recommended by the SMRS (National Autism Center, 2009). These quality indicators for group experimental and quasi-experimental research in special education (Gersten et al., 2005; Horner et al., 2005; Odom et al., 2005) were used to inform and justify the methodological design and method applied to this study.

4.1.2 The Pilot Study

A pilot study involving two participants with HFASD was conducted prior to the full scale study (see *Chapter 5*). This trial allowed the researcher to gauge the suitability of the selected instruments and measures chosen for participants specified in the inclusion criteria based on age, diagnosis, and reading ability. In addition, the pilot study provided an opportunity for adaptations and/or modifications to be made to the method, procedures, and the App intervention prior to the full scale study. For example, in the related field of psychosocial interventions and individuals with ASD, White, Keonig and Scahill (2006) have advised that a pilot study is an important and initial phase of a main study and allows for the formulation and systematic examination of intervention techniques. This may be a simple AB design as utilised by Yang, Schaller Huang, Wang, and Tsai, (2003) for enhancing social behaviours for children with autism in general education classrooms. The pilot study followed the same AB design (pre post intervention) and adhered to ethical approval concerning informed consent and recruitment of participants as the main study.

4.1.3 The Main Study

The main study in this thesis used a single subject quasi-experimental case design across nine participants randomly assigned to one of two treatment groups. Single-subject case designs typically include multiple participants in a single study (e.g., 3 to 8), but can also involve a single participant (Horner et al., 2005). Horner et al., (2005) explained that external validity of a single case study is improved if the study includes multiple participants, settings, materials,

and/or behaviours. It is typical for single-subject studies to demonstrate effects with at least three different participants (Horner et al., 2005). Rose and Grosvenor (2013) have explained that using the same individual/s and their initial baseline data as the 'control' and comparison for the intervention data that followed, was often a more trustworthy measure of change in special education research.

The pilot and main study utilised a mixed method approach which allows for the collection of both quantitative and qualitative data. The reason for a mixed method approach was to ensure that the data collected provided not only a measured analysis through the collection of quantitative data, but balanced these results against qualitative elements pertinent to the behaviour of participants throughout the assessment periods (Guralnick, 1999; Odom, 2005). This approach within a case study framework incorporates descriptive as well as evaluative information for the purpose of enriching quantitative results (Stake, 1995). Research conducted in naturalistic contexts such as educational environments can be challenging as quantitative results are often affected by uncontrollable variables (Rose & Grosvenor, 2013). To counter these issues, a mixed methods approach within these contexts has been acknowledged by researchers as a valuable way to provide a complementary information set to more clearly explain quantitative results (Li, Marquart, & Zercher, 2000; Odom et al., 2005). This approach is often more effective than one single method.

One of the key design features of single subject quasi-experimental and experimental research is repeated assessment (Horner et al., 2005; Nock, Michel & Photos, 2007) and "systematic measurement of a dependent variable before, during, and after the active manipulation of an independent variable (e.g., applying an intervention)" (Kratochwill,

Hitchcock, Horner, Levin, Odom, Rindskopf & Shadish, 2010, p. 339). Three main assessment points were assigned to the main study between two treatment groups. Five participants were assigned to treatment Group 1 and were assessed at baseline, Post-test 1 after receiving the intervention, and again after a maintenance period (without intervention) at Post-test 2. Four participants assigned to treatment Group 2 were assessed at two baseline points and again after the intervention at Post-test 1. The purpose of a two group allocation was to determine the intervention effect under different treatment conditions where each participant acted as their own control. This quasi-experimental approach was used as an alternative to adopting a true experimental design study with one group as the control and the other as the intervention group. A true experimental approach would require demonstration of group equivalence (Horner et al., 2005) which can be problematic in special education research. The diagnoses of ASD and also HFASD are on a broad continuum, and together with small sample sizes, this reduces the likelihood of achieving a true equivalence of groups (Gersten et al., 2005; Li et al., 2000; Rose & Grosvenor, 2013). In addition, all nine participants were located across different school settings. Under these circumstances Rose and Grosvenor (2013) have recommended that that an individual (single subject) rather than a group cohort design is often required due to the lower incidence of students with a specific impairment in any one location and the variability of differing contexts.

In regards to the present study, single subject design was most appropriate for developing the methodological framework to account for the heterogeneous nature of students with ASD. This is important considering the diversity of language and comprehension strengths and weaknesses within each individual's profile. Furthermore, a quasi-experimental design enabled

the impact of the intervention to be measured against each individual's profile as the control and comparison to answer the research questions:

"Can App software be designed to support measurable gains in reading comprehension for students with HFASD?"

"Considering the heterogeneous nature of individuals with HFASD, what attributes or characteristics influence students' results after using the software?"

4.2 Participants

Conducting this research required addressing strict guidelines and receiving approval as set out by the National Statement on Ethical Conduct in Human Research (National Health and Medical Research Council, 2008). All participants were required to be treated in a just and respectful manner providing "for the child or young person's safety, emotional and psychological security, and wellbeing" (National Health and Medical Research Council, 2008, p.56), and to minimise the possibility of harm to any person involved in the study. Students with HFASD were recruited throughout the state of Tasmania through the Department of Education Tasmania state schools (see Appendix F) and Tasmanian Catholic Education private schools (see Appendix G). Permission to conduct the research was provided by the relevant Human Research Ethics

Committee (Appendix A), school authority, the participants' classroom teacher, and the participants and their parents or guardian (see Appendices H through K).

Initial criteria for inclusion in the present study were for students between nine and twelve years of age with a formal diagnosis of HFASD. The age for inclusion was adjusted after conducting the pilot study to incorporate students from seven years of age. There was an additional requirement that participants were able to recognise and read words at or around their chronological age. The ability to decode and recognise words at an appropriate age level was confirmed by the students' regular classroom teachers. Exclusionary criteria were also used to identify suitable participants for this research. These consisted of: a diagnosed visual or hearing impairment; other known genetic syndromes recognised to affect cognitive responses; intellectual disability; and mental illness. The aim was to be specific regarding the participants involved in the research, with the target cohort to be students with HFASD.

Initially, two participants fitting the inclusion criteria were recruited for a pilot study and a further nine participants were recruited for the main study within an age range of seven to twelve years. Eight of these students had a confirmed diagnosis of HFASD; one student had a preliminary diagnosis of HFASD from testing administered by a registered child psychologist. This participant was awaiting further testing and formal diagnosis. Participants with a confirmed diagnosis had received a formal assessment through the Tasmanian Autism Diagnostic Assessment Service (TASDAS) using the Autism Diagnostic Observation Schedule (ADOS; Lord, Rutter, DiLavore, & Risi, 2003). The ADOS has become the standard instrument for assessing autism across age, developmental level, and language skills, and the Autism Diagnostic Interview – Revised (ADI-R) (Lord, Rutter, & Le Couteur, 1994). The ADI-R is a

comprehensive structured interview that provides a thorough assessment of individuals suspected of having autism spectrum disorders.

4.3 Materials - Instrumentation

The study involved the collection of quantitative data from standardised tests of verbal intelligence (expressive and receptive language), phonological awareness, reading comprehension, and reading attitudes. These instruments were used in pre and post-tests to assess aspects affecting reading ability but more specifically, the dependent variable (reading comprehension levels) in order to indicate specific changes resulting from the introduction of the intervention (i.e. engagement with the App).

4.3.1 PPVT-4 and EVT-2

The "Peabody Picture Vocabulary Test" (PPVT-4; Dunn & Dunn, 2007) measures the receptive (listening) vocabulary of children and adults. The PPVT-4 has been identified as a reliable and valid measure of children's receptive language (Pae, Greenberg, & Morris, 2012). Important for this study, the PPVT-4 has also been identified as a reliable and valid measure of receptive language when assessing students with ASD and HFASD (Dixon, Carman, Tyler, Whiting, Enoch, & Daar, 2014).

The "Expressive Vocabulary Test, Second Edition" (EVT-2; Williams, 2007) measures the expressive (speaking) vocabulary of children and adults. The EVT-2 has been identified as a reliable and valid measure of children's expressive language (Smith, 1997). Research by Moyle

and Long (2013) has also identified it as a valid and reliable measure of expressive language for students with ASD and HFASD. Both the PPVT-4 and the EVT-2 tests take approximately 10-15 minutes to administer.

4.3.2 Phonological Abilities Test – PAT

The "Phonological Abilities Test" (PAT; Muter, Hulme, & Snowling, 1997) is designed to be used for children aged 4 – 7 years at risk of reading failure, and with older children, as a diagnostic tool for assessing the nature and extent of a child's letter, word, and phonological weaknesses. The test consists of four phonological awareness sub-tests, letter knowledge, and also speech rates subtest. The PAT has been reported to be a valid and reliable measure for children's early reading development by Molfese, Modglin, Beswick, Neamon, Berg, Berg, and Molnar (2006) and Muter and Diethelm (2001). The PAT takes approximately 15 minutes to administer.

4.3.3 Comprehension – TORCH: 3

The Tests of Reading Comprehension, 3rd edition (TORCH:3; Mossensen, Stephanou, Foster, Masters, McGregor, Anderson, & Hill, 2003) is a standardised Australian test which measures reading comprehension levels. The TORCH: 3 has been tested in Australian schools and compares student performance with an Australia-wide sample of over 7000 students from school years 3 – 10 and are standardised at each year level. Students are presented with a single passage of text together with a retelling of the passage in different words in the form of a cloze

activity that contains gaps corresponding to details in the original text. In the present study, three narrative passages were used after consideration of the reading ability of participants. The narratives chosen were both fiction and non-fiction passages. The tests identify specific strengths and weaknesses in reading comprehension such as literal, interpretive, and inferential meanings, and synthesis of information. The TORCH: 3 are not timed tests and require approximately 20 minutes to complete. The assessment involves students reading silently rather than aloud, therefore does not assess oral reading fluency as a measure of reading comprehension (Department of Education and Early Childhood Development [DEECD], 2006). Students' raw scores are obtained and then scaled with comparative TORCH: 3 scores. A test/retest reliability coefficient of 0.91 to 0.93 is reported by the authors for different TORCH: 3 passages.

The TORCH: 3 has demonstrated to be a reliable and valid measure of students' reading comprehension based on Australian research by Bornholt (2002) and Australian and New Zealand research conducted by van Kraayenoord, Beinicke, Schlagmuller, and Schneider (2012).

4.3.4 App Comprehension Test

The App comprehension test, developed by the researcher was created from the first chapter of the App intervention (see Appendix L), and administered after the TORCH: 3. The App comprehension test consisted of 24 questions that relate to basic facts in the story (who, what, when, where), and nine higher level inferential questions such as "The text suggests that Reddy Fox could not be _____". The test is administered in the same manner as the TORCH: 3 where the student reads a narrative passage and then answers questions set in 'cloze' format that retell details of the passage using alternative wording. Gersten et al. (2005)

described one of the challenges in crafting a study is to ensure that the selection of measures are well aligned with the intervention, and are broad and robust enough "to (a) avoid criticism for teaching to the test through the specific intervention, and (b) demonstrate that generalizable skills have been successfully taught" (p. 158). The App comprehension test was created from the first chapter of the App and therefore directly aligned with the intervention through testing the comprehension skills to be taught (Tomlinson, 2014). All nine participants who were administered the test at baseline, reliability, and post-test points, were not made aware of their correct or incorrect responses. This ensured there could be no modification made to answers from prior knowledge of correct or incorrect responses in subsequent administrations of the test. To estimate the reliability of this test, all nine students in the main study of this research undertook the test and repeated it without intervention two weeks later in order to demonstrate stability and reliability of the instrument (Gersten et al., 2005).

4.3.5 Reading Attitude Survey

Participants' attitudes towards reading are measured using an adapted version of the Elementary Reading Attitude Survey (McKenna & Kear, 1990). This survey (see Appendix M) was normed with over 18,000 students in Years 1 - 6 across 38 American states. The original survey was constructed using a pictorial rating scale equating to four levels of response, mirroring that of a Likert; strongly agree, agree, somewhat disagree, disagree. These responses were chosen using the Garfield cartoon character facial expressions ranging from very happy to very sad. The survey was adapted for the present study by removing the facial expressions responses, as understanding facial expressions is commonly known to be problematic for

children diagnosed with autism (Lord et al., 2006). Additionally, some questions were modified for the present study to reflect attitudes on 'reading' as opposed to 'reading books'. For example, 'I like starting a new book' becomes 'I like starting a new story'. The adaptation includes additional questions such as 'I like reading on the computer or iPad', to reflect changes in text delivery methods since the original survey was formatted. The survey was explained to participants by the researcher before answering the questions, emphasising to participants that this was not a test, and there were no correct or incorrect responses. This survey was completed by participants at Baseline 1 data collection only. The reason for including this test was to obtain qualitative information to provide a broader description of each participant's reading profile and reading behaviours.

4.3.6 The App and Reporting Function

The App described in *Chapter 3* was deployed as the method of delivering the intervention and a means of reporting on the students' reading performance within the text. This instrument was not commercially available until after the main study to ensure that participants would have had no opportunity to access the App prior to commencing the intervention. The software associated with the App provides data through an electronic spreadsheet that reports on the student's summative performance on the embedded questions once the student has finished reading. For the purpose of the present study, data were collected on the complete text post-intervention. The spreadsheet showed which particular item or items the student had difficulties with by reporting error rates on responses (Walker, 2014). This feature was not available for the pilot study but was later included to further inform the main study results. Reviewing the correct

or incorrect responses made it possible to estimate specific areas of weakness in comprehension that needed additional attention or even extension work. An analysis of the students' errors and successes provided relevant information about the students' comprehension performance related to: their literal comprehension ability; their ability to handle pronouns and anaphoric meanings in the text; their ability to correctly imply meaning from the text; and their ability to sequence information and to use higher level thinking associated with the narrative story and its characters (see Table 3.2 for examples).

4.3.7 Procedure and Data Collection

The data collected measured the changes to students' reading comprehension performance as a consequence of their engagement with the App. The tests were administered by the researcher who had prior research experience in administering these and similar reading assessment instruments in schools. This approach was chosen due to budget restrictions for a research assistant, and is a common limitation associated with PhD projects. Data were collected in the participants' own school setting as children diagnosed with ASD are sensitive to changes in routines and unfamiliar situations (Lord et al., 2000; Lord et al., 2003). For testing, the participants worked individually with the researcher in a quiet room set aside from the rest of the class and general school operation. This was an existing and formally established procedure for the participants in the present study as they worked regularly with teacher aides and assistants for other remedial lessons.

Interviews conducted with each of the participants over the course of the pilot and main studies contributed valuable qualitative information to the research. Questions included the way

in which each participant accessed the text in App (audio and/or visual) and their favourite function/s like the 'picture builder'. These interviews also provided more of an insight into the personal elements or 'qualitative' characteristics of each participant, and were incorporated to afford a 'mixed methods' approach. Examining quantitative and qualitative data together can provide additional evidence to assist in understanding who the intervention is successful for and why (Horner et al., 2005; Li et al., 2000).

The two participants with HFASD in the pilot study were located in the same school setting and classroom and the nine participants with HFASD in the main study were located across different school settings. Testing for the pilot study and the main study was undertaken with each participant between 9.30am and 11.45am on regular school days. The participants in the pilot study completed baseline tests and then were provided with the App intervention. Six weeks later the researcher returned and administered the post-tests after the participants had completed the App intervention.

The intervention in the main study was conducted over a six week period (not including four weeks of pre and post testing). After baseline tests were completed for all nine participants and the App comprehension test was repeated two weeks later as a reliability check (Harvill, 1991), Group 1 participants were allocated the App intervention. Group 1 participants were required to use the App intervention independently for a minimum of twice a week and for approximately 30 minutes each session on designated days and times confirmed by their teacher. Those students assigned to Group 2 received their regular program of classroom instruction. At the completion of the six week period all nine participants from both groups were re-tested and the iPads that had been provided to the Group 1 participants were returned to the researcher for

removal of data concerning each participants' use and error rates (see *Chapter 6* results). The researcher questioned each Group 1 participant on the way they used the App and the features that they liked or did not like. Once these data were obtained, the iPads were cleared and re-loaded with the App and the intervention was implemented in the same format as previously discussed, for the four remaining participants in Group 2. On completion of the six week intervention, the iPads were again returned to the researcher from these four participants, the data removed for analysis (see *Chapter 6)*, and all nine participants were tested for a final time. An overview of the study design is provided in the following *Figure 4-1* Research Framework.

4.4 Research Framework

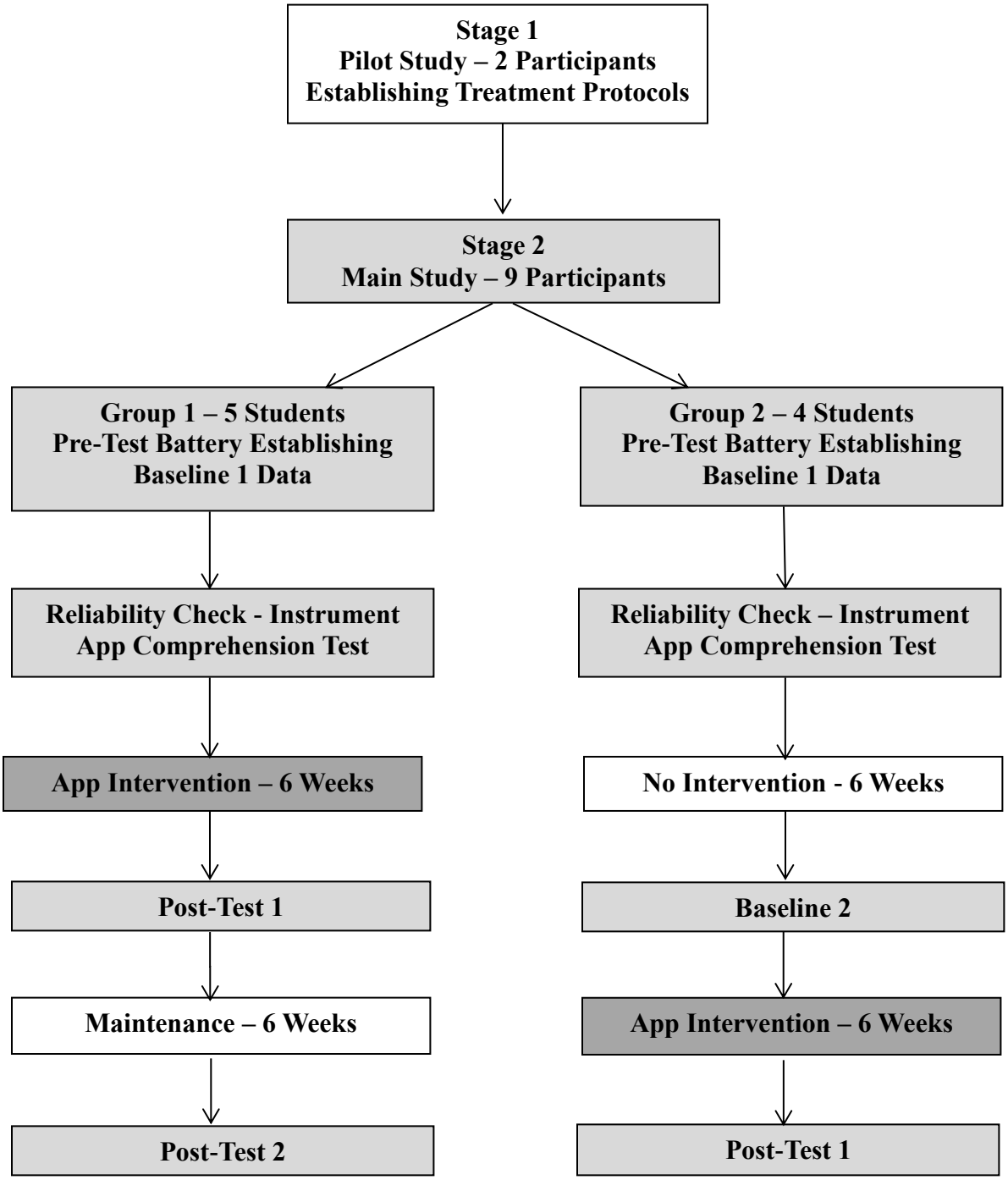

Figure 4-1 Research Framework.

The critical difference between each treatment group was: following the Baseline 1 and Reliability tests Group 1 were administered the App intervention followed by Post-tests 1 and 2 after completing the intervention; and Group 2 received the Baseline 1 and Reliability tests and then an extended Baseline 2 test before receiving the App intervention. This was then followed up with their Post-test 1. That is, while Group 1 were receiving the intervention, the Group 2 participants were in an extended baseline period, and while Group 2 participants were receiving the intervention, the Group 1 participants were in an extended maintenance period. The variation in terms of pre-test and post-tests was to enable the researcher to determine effects under different treatment conditions.

This chapter has described and justified the methodology and procedures set out in order to address the aims and the research questions central to this investigation. *Chapter 5* will discuss the implementation of the intervention, and the results and findings of the pilot study employed to establish treatment protocols for the main study discussed in *Chapter 6*. The proceeding chapters will fulfil further aims of the present study which are:

4 Apply the App as an intervention.

5. Evaluate the effectiveness of the approach in applied settings by measuring the key factors that underpin the development of effective reading comprehension skills in students with HFASD;

6. Analyse the results and report the findings.

Chapter 5 – Pilot Study

5.1 Introduction

A pilot study commenced in the fourth term of 2013 with the primary purpose of informing the methodological design of the main study. As discussed in the previous chapter, the pilot study was conducted to establish treatment protocols and as such served as 'proof of concept' for the main study design and measures.

Stage 1
Pilot Study – 2 Participants
Establishing Treatment Protocols

Figure 5-1 Stage 1 Pilot Study

5.1.1. Participants

Two male participants identified as meeting the inclusionary criteria for the study were referred through the Tasmanian Department of Education learning support services. These participants attended the same school, and were situated within the same grade (Year) 5 and 6 class. Both participants were identified through school records as being diagnosed with High-Functioning Autism. Their reading levels and fluency were at age expectation as confirmed through their classroom teacher. The school principal, teacher, parent/s, and each participant provided written consent prior to the commencement of the pre-data collection phase (see Appendices H to K). All participants' names have been replaced with pseudonyms to protect

their privacy. Tim was aged 12 years and six months and Sam 12 years and nine months. The researcher noted that Tim displayed signs of social impairment relative to the characteristics of autistic disorder, whereas these social characteristics were not as evident in Sam. Both participants were familiar with the use of an iPad prior to commencing the intervention. The researcher provided instructions and a demonstration on navigation of the App before supplying each participant with a university supplied iPad loaded with the intervention software.

5.1.2. Instruments

As part of the pre-test battery, each participant was administered the "Peabody Picture Vocabulary Test" Form B (PPVT-4; Dunn & Dunn, 2007) which measures the receptive (hearing) vocabulary of children and adults. This was followed by the "Expressive Vocabulary Test" Form B, Second Edition (EVT-2; Williams, 2007) to evaluate expressive vocabulary attainment. To rule out any phonological weaknesses which could contribute to deficits in comprehension, the "Phonological Abilities Test" (PAT; Muter et al., 1997) was administered. This test consists of four phonological awareness sub-tests, letter knowledge, and also a speech rate subtest. The students' reading comprehension levels were measured in written format using the "Tests of Reading Comprehension", 3rd edition (TORCH:3; Mossensen et al., 2003). The comprehension test chosen, 'In the Mall', is recommended for Grade (years) 5 – 7 levels and is classified as fictional. A comprehension test developed by the researcher created from the first chapter of the App intervention was administered after the TORCH: 3. The test consisted of 24 questions that related to basic facts in the story (who, what, when, where), and nine higher level inferential questions. The participants' attitudes towards reading were measured using an

adapted version of the Elementary Reading Attitude Survey (McKenna & Kear, 1990). All tests were completed over two mornings between 9.30am and 11.45am within the participants' own school setting.

5.2 Results of Pre-tests

Results of the "Peabody Vocabulary Test" (PPVT-4) indicated that Tim and Sam's results fell within the upper average range level with their receptive vocabulary, however, a similar result was not achieved with the "Expressive Vocabulary Test" (EVT-2). Expressive vocabulary levels fell within the lower range of average for Tim, and conversely at the higher range of average for Sam. Both participants reached ceiling levels on all four sub-tests of the "Phonological Abilities Test" (PAT) ruling out any decoding deficits. Reading comprehension levels as measured by the TORCH: 3 scale score levels were within norm limits for both participants at a TORCH: 3 score of 48.9 for Tim, and a TORCH: 3 score of 51.5 for Sam. This was despite higher than average receptive vocabulary scores for both participants and a higher than average expressive vocabulary score for Sam. The reading attitude survey recorded that Tim was very happy reading at home, reading on a computer or iPad, and using a dictionary but did not like reading at school, doing reading worksheets, reading lessons, reading aloud or having reading tests. The favourite text types for Tim were information books and electronic texts. Sam indicated on the reading attitude survey that he did not like reading in school, reading different kinds of stories, reading school books, reading aloud or having to do a reading test. Sam also preferred reading at home, in school holidays, and reading on a computer or iPad. His favourite types of texts were chapter books. After reading the first chapter of the story

unassisted, the scores from the App comprehension test were 12 out of 24 (50% correct responses) for Tim with a slightly higher error rate across inferential than literal questions. The unassisted reading of chapter one for Sam reported 16 questions correct out of a total of 24 questions (66% correct responses). The correct responses were evenly weighted across inferential and literal comprehension questions.

5.3 Intervention

After pre-testing was completed and Tim and Sam received the iPads and App intervention and the classroom teacher was provided with a check-list (see Appendix N) to record the days and times each participant used the App. Due to the self-directed nature of the App intervention and the age of participants, it was not necessary for the teacher to provide instructional support. These unassisted sessions were conducted in quiet reading time either just prior to or after lunch time breaks. The teacher was able to record specific remarks and comments related to participants' usage or engagement with the App intervention as well as the frequency and duration of engagement.

Tim completed all 25 chapters of the App intervention in four weeks with a single session in weeks one and two and twice weekly sessions in weeks three and four. The classroom teacher noted that in week 3 when students were also attending a swimming program that Tim was "tired, easily distracted and it was difficult to get participant to focus on reading task. In the following session it was noted that he was more focused as he was away from the rest of the group and it was held prior to the swimming lesson.

Sam completed all 25 chapters the intervention in two weeks with four reading sessions in week one and two sessions in week 2. The classroom teacher reported that in week two he participated in a small group comprehension task which was reading for information and reporting on renewable energy. In week one, the teacher noted that he was "very confident in how quickly he was getting through chapters" and in week two that he "had become a little bored with the story."

5.4 Results

Tim

Tim completed the App intervention in four weeks and remarked to the researcher that he really enjoyed reading the App. His positive engagement was also noted on the Teacher check-list by his classroom teacher. Tim explained that he liked the story and the ability to listen to parts of the story when he wanted to, as well as do the activities as he read the different parts. In particular, he said he liked using the 'picture builder' (the function supporting visualisation). He was motivated by the App and wanted to know where he could get the next story to follow on from the intervention text.

Results of the pre-tests indicated that Tim's receptive vocabulary (PPVT-4) was above average at a 66 percentile level. This result increased marginally on the post-test to 68%. Tim's expressive vocabulary (EVT-2) was lower than average on the pre-test at a 30 percentile level. A retest after the intervention noted that he was at 50 percentile, or age equivalence. The Phonological Abilities Test indicated that Tim had no phonological weaknesses as results were at ceiling level. Reading comprehension levels on the TORCH: 3 were recorded as average on both

pre and post-intervention tests however, results on both tests indicated problems with locating and interpreting information, and understanding inferences. Scores on the App comprehension test showed a change with an initial pre-test score of 12 out of 24 (50% correct) and post-test result of 18 out of 24 (66% correct) (see *Figure 5-3*).

Sam

Sam completed the intervention in two weeks. His teacher noted how determined he was to get through the App as quickly as possible. In week two he remarked that he would rather read his own book and stated, "I don't want to be rude or offend, but I find the App a bit childish." Sam also made these comments to the researcher when discussing his use of the App, and explained that he really enjoyed the 'picture builder' function of the App. Results of the pre-tests showed Sam's receptive vocabulary (PPVT-4) in the upper average range at a 73 percentile level, rising slightly to 75 percentile on Post-test data (see *Figure 5-2)*. Sam's expressive vocabulary results (EVT-2) were in the upper range of average at an 81 percentile level rising to 84 percentile on Post-test results which was at one standard deviation above average. The Phonological Abilities Test indicated that Sam had no phonological weaknesses as results were at ceiling level. Reading comprehension levels on the TORCH: 3 were recorded as average on both pre and post-intervention tests with results showing deficits in understanding inferences and embedded meanings. Results of the App comprehension test were 16 out of 24 (66% correct) on the pre-test rising to 19 out of 24 (79% correct) on the post intervention test (see *Figure 5-3)*.

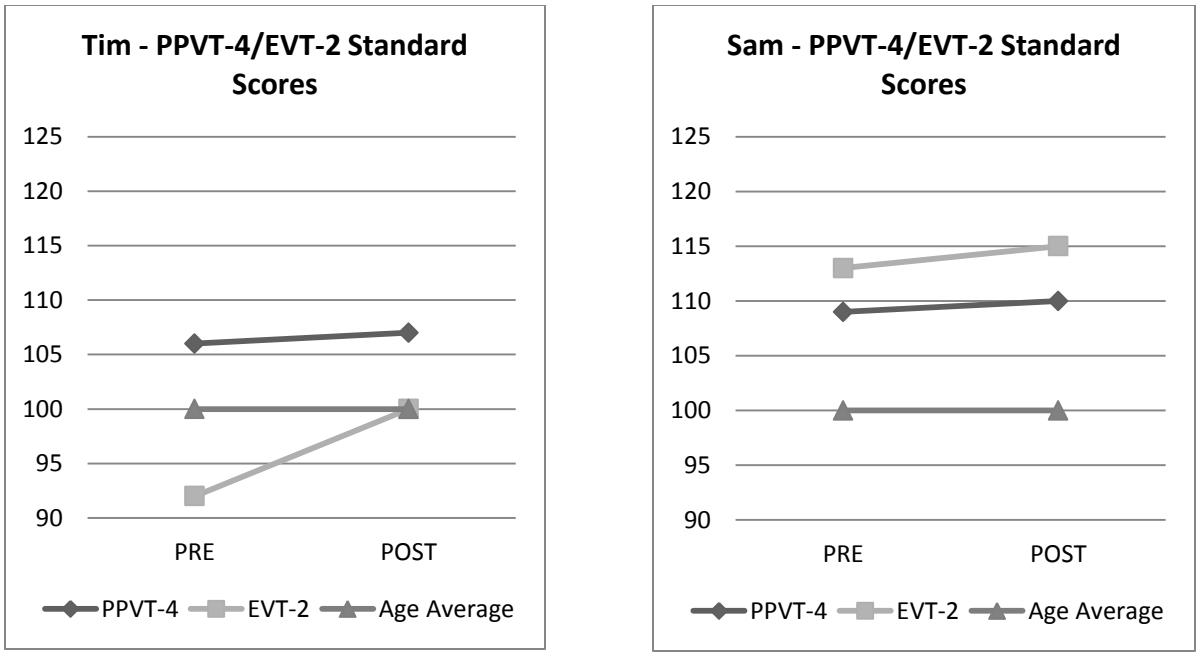

Figure 5-2 Comparison of vocabulary profiles showing age equivalence between Tim and Sam on the PPVT-4 and EVT-2 pre-post intervention

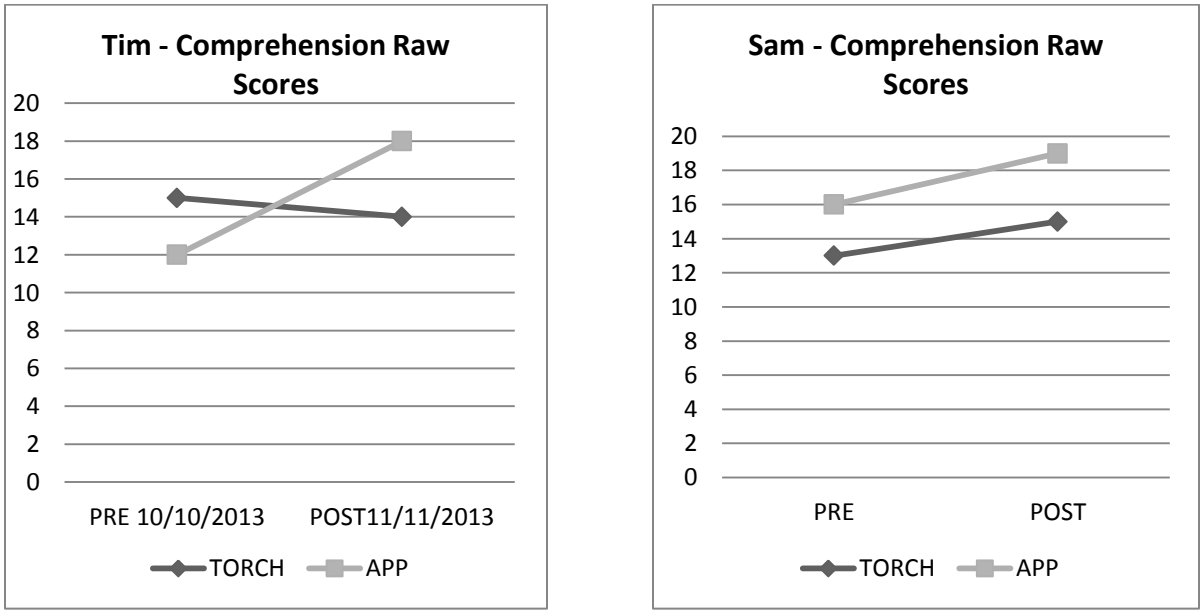

Figure 5-3 Comparison of vocabulary profiles showing age equivalence between Tim and Sam on the PPVT-4 and EVT-2 pre-post intervention

5.5 Discussion

The purpose of this pilot study was to determine if explicit teaching strategies embedded into App software could improve reading comprehension in students with HFASD. This is in part to inform and refine the design of a larger study in response to the need for effective interventions in the field of special education, specifically students with HFASD, and the limited availability of empirical evidence concerning current educational technologies (Kagohara et al., 2013; Knight et al., 2013; Stephenson & Limbrick, 2013). The results showed differing responses in that one student (Tim) made higher gains in some areas than other areas, which was not surprising due to the heterogeneous profiles of individuals with HFASD (Nation & Norbury, 2005).

5.5.1 Key Findings

Differing profiles for students with HFASD are not uncommon within the literature (Nation et al., 2006). In particular, Kjelgaard and Tager-Flusberg (2001) noted that one-quarter of their sample group of 88 children with ASD could be classified as having relatively normal language skills and within this sample, 80% did not show more than one standard deviation difference between their PPVT-4 and EVT-2 scores. The remainder showed discrepancies of more than one standard deviation on PPVT-4/EVT-2 comparisons, with 16% recording higher on the PPVT-4, and 4% higher on the EVT-2. It needs to be stated that although expressive and receptive language skills are not static, they typically do not respond quickly to short-term interventions and so measures such as the PPVT-4 and the EVT-2 are considered to be better at identifying long-term changes in expressive and receptive language (Williams, 2007). Although

the change in the students' receptive and expressive language measures were not expected over a four week intervention, changes in vocabulary levels have, however, been reported in other pre and post intervention studies involving computer assisted instruction (Whalen et al., 2010). The Phonological Abilities Test indicated no weaknesses with either participant on any of the sub-tests, therefore ruling out word level decoding problems often associated with comprehension deficits (Gough & Tunmer, 1986; Nation & Norbury, 2005; Perfetti et al., 1996). In accordance with the theory that after accounting for word recognition and decoding, reading comprehension is closely linked to oral language ability (Nation & Norbury, 2005; Nation & Snowling, 2004), changes in Tim's expressive vocabulary may correlate with his improved result in the post intervention App comprehension test.

Comprehension levels recorded by the TORCH: 3 indicated little change between pre-post intervention measures, with both participants at their age equivalent standards. Again, achieving significant change on reading comprehension using a more global measure of reading comprehension, such as the TORCH: 3, over a short duration is difficult (Woolley, 2011). While the global measure of reading comprehension was not sensitive enough to identify the students' increase in reading comprehension over the duration of the intervention, the measure directly linked to the task (the App comprehension test) did identify change and improvement. On this point Tomlinson (2014) has argued that the closer the connection and alignment between the instructional task and the assessment task, particularly for students with special education needs, the greater the likelihood that the teacher will be able to effectively monitor the students' true progress. On the App comprehension assessment questions, Tim recorded a pre-post gain of 21% and Sam 12.5%. The questions in the App comprehension test were structured in the same

'cloze' format as the App which allows for a finer-grained analysis of any changes post intervention (Tager-Flusberg, 2000). This finer-grained analysis of the App comprehension test is relevant when more closely examining Tim's pre and post intervention answers. Post-test data recorded improvements in correct responses of literal, and some inferential information. For example, when responding to "the text suggests that Reddy Fox could not be _____", his pre intervention answer of 'lying' was incorrect. After working with the App intervention, his correct response was 'trusted.' This suggests that after engaging with the App intervention, Tim was re-reading and/or interpreting the text at a deeper level. Results for Sam were also positive, even though his gains were smaller. Sam's main improvements were seen in two questions related to literal understandings or sourcing answers directly from text, and one concerning inferences. These improvements indicate that both Tim and Sam were better able to generalise their knowledge from the App intervention to the aligned assessment tasks through sustained practice and explicit focus on the embedded teaching strategies within the App intervention (Duker et al., 2004; O'Connor & Klein, 2004).

5.5.2 Implications for Practice

The critical implication indicated by this pilot study is that it is possible to develop App software for students with HFASD and this software can assist some students with HFASD in improving their reading comprehension skills. One of the key findings of the piloted study was that the iPad and App software were able to be incorporated into a regular classroom program as an independent learning tool. Taking into account the results and the students' comments, these findings show that it is possible to embed explicit teaching strategies within new platforms of

technology to engage students and also to support and improve the students' learning outcomes. Both students were very engaged with the visual 'picture builder' (the function supporting visualisation) that was designed for this App, and they liked the ability to revisit the text using the audio feature as well as responding to the embedded questions. Therefore, educational software that is motivating and engaging *as well as* pedagogically sound, could be associated with better student outcomes (Falloon, 2013; O'Malley et al., 2013). There are accounts in the research literature of improved levels of motivation and engagement with software, but accounts linking motivation and engagement with effective pedagogical practice within the technology are less common (Stephenson & Limbrick, 2013). As a result, care must be taken when teachers, parents, practitioners and educators assess the pedagogical elements of new software and technology, as motivation and engagement alone may not equal academic gain. Tim's response can highlight this association between engagement and pedagogically sound software by his results and through his comments concerning his dislike of reading in class and answering questions from the teacher about his reading. After the intervention, he discussed how he really enjoyed using the App as an independent and self-directed reader, and made no mention of any problems associated with answering the embedded questions within the App. The findings of this pilot study are consistent with previous research suggesting that for some individuals with ASD and HFASD this technology can be a meaningful platform for delivery of teaching strategies (Armstrong & Hughes, 2012; Kagohara et al., 2013; Knight et al., 2013). Furthermore, these technologies may assist in ameliorating common problems students with HFASD can have with oral and face-to-face teaching instruction in a regular classroom environment (Baron-Cohen et al., 1985; Lawson, 2003; Ricketts et al., 2012).

Having an understanding of the cognitive processing profiles of students with HFASD (Happe & Frith, 2006) provides a more informed framework to develop evidence-based reading comprehension strategies and resources. The findings of this pilot study support those of other researchers who have found that students with HFASD often have a bias toward visual processing (Neumann et al., 2011; Roth et al., 2012). This may be one reason why the 'picture builder' was an attractive feature of the App for the two participants. Many 'typically developing' students may acquire the strategies which support the integration of information within text into meaningful information without direct intervention or targeted instruction. Unfortunately, without visual aids and some level of explicit and sustained practice designed to support and develop the appropriate comprehension skills, many students with HFASD may not easily acquire these comprehension skills (Knight, 2010; Williamson et al., 2012).

The findings of the pilot study lend support to the theory that students with HFASD can enhance their engagement and development of reading comprehension by adopting new technology and engaging with evidence-based strategies, such as explicit scaffolded instructions, the construction of visual imagery, and specifically targeted questioning strategies (Colasent & Griffith, 1998; Knight et al., 2014; O'Connor & Klein, 2004; Whalon & Hart, 2010). The feedback from the students and their teachers in the pilot study also suggests that educational technology, when pedagogically designed, may be an important step in assisting students with HFASD towards independent learning (Armstrong & Hughes, 2012).

5.5.3 Implications for Future Research

Although the results from this case study research showed positive effects from the intervention, one of the purposes of this pilot study was to inform the design and implementation of a broader study. Whilst the standardised instruments used in this research, such as the PPVT-4, EVT-2, TORCH: 3, and PAT are considered acceptable in providing reliable pre and post intervention data, these more global measures were not as effective in monitoring the students' development of reading comprehension over a short duration as the App comprehension test (Williams, 2007). This reinforces the Tomlinson (2014) argument that the closer the connection and alignment between the instructional task and the assessment task, the greater the likelihood that the teacher can effectively monitor students' true progress. However, as the App comprehension test was not a standardised instrument, it required a reliability test (Gersten, Fuchs, Compton, Coyne, & et al., 2005). This was addressed in the main study method through a repeated delivery shortly after the collection of Baseline 1 data and is identified as the Reliability test. Repeated measures on dependent variables, such as the App comprehension test, identify a participant's performance patterns prior to the intervention, particularly in extended baseline, and provide comparisons of performance patterns post-intervention (Horner et al., 2005). The PPVT-4, EVT-2, TORCH: 3, and the PAT have demonstrated a purpose in the research as they established the academic and overall cognitive competency of the cohort of students under investigation. Given the heterogeneity across autistic profiles, it can often be difficult to compare key variables. This highlights the importance of providing enough information concerning the individual cognitive characteristics of each participant with qualitative information concerning attitudes, teacher's remarks, check-lists and post intervention comments, to clearly describe the impact of the intervention from an individual level (Gersten et

al., 2005). Furthermore, how this description in both qualitative and quantitative data can contextualise results and findings to inform and guide evidence-based practice (Brantlinger, Jimenez, Klingner, Pugach, & Richardson, 2005).

Chapter 6 – Implementation of Main Study and Results

6.1 Introduction

After a review of the pilot study results and considerations raised from the findings in *Chapter 5*, the main study was conducted to investigate the following research questions:

> "Can App software be designed to support measurable gains in reading comprehension for students with HFASD?"

This chapter will also address the sub-question:

> "Considering the heterogeneous nature of individuals with HFASD, what attributes or characteristics influence students' results after using the software?"

The findings and comments from the students involved with the pilot study did raise some issues that needed addressing in the main study. The students' reading comprehension improvements, as measured by the students' end of intervention performance on the App comprehension test, needed to be better clarified. For instance, was this improvement on the App comprehension test caused by the students' engagement with the intervention or were the change in scores associated with an error of measurement using a non-standardised assessment tool? To address the possibility that it may be standard error of measurement associated with a test, intervention, re-test situation, one method to control for a standard error of measurement (Harvill, 1991) is to do a test retest of the assessment instrument before the start of the intervention within a short time span between the tests so the same test is administered under

slightly different conditions. This procedure helps to identify the reliability of the test or instrument (Harvill, 1991).

A second issue that arose from the pilot study related to comments from one of the participants. This concerned his thoughts that the story was 'a little childish' and therefore not an engaging theme. Students with HFASD have been noted to have a more restricted range of interest than students without the disorder (Klin et al., 2000). For example, in terms of reading and students with ASD, there is some evidence that they have more of a preference for stories which involve tangible objects, such as stories about cars and trains, in comparison to stories involving less tangible objects, such as fairy tales (Dunst, Trivette, & Hamby, 2012).

Traditional thinking is that children's interests in stories change over time, with the main change from more narrative texts at primary school level, to more expository texts in secondary school (Woolley, 2011). In relation to story genres, the indications are that stories in the middle primary school have more of a focus on animals, family and sport based settings as well as fantasy and explorative stories, however, by upper primary school, students show more interest in stories that have elements of horror, adventure, science fiction, war, and mysteries (Knowles & Smith, 2005). The concern was that the text, "The Adventures of Billy Possum" may be of more interest to students with HFASD in the lower and middle primary school grades, than students with HFASD in the upper primary school grades.

As a result, changes were made to the inclusionary criteria concerning the age range of possible participants for the main study. This was amended from an initial selection age of nine years to a lower limit of seven years of age to ensure that the App story, from a reading interest perspective for the participants (Knowles & Smith, 2005), would be more age-appropriate, and at

an instructional level for the majority of participants (Duke & Pearson, 2002; Su & Draper Rodriguez, 2012; Woolley, 2011). Ethical approval for the adjustment in participants' age was sought through an amendment to the original ethics application and approved as per relevant guidelines addressed through the National Statement on Ethical Conduct in Human Research (see Appendix B) (National Health and Medical Research Council, 2008).

6.2 Method

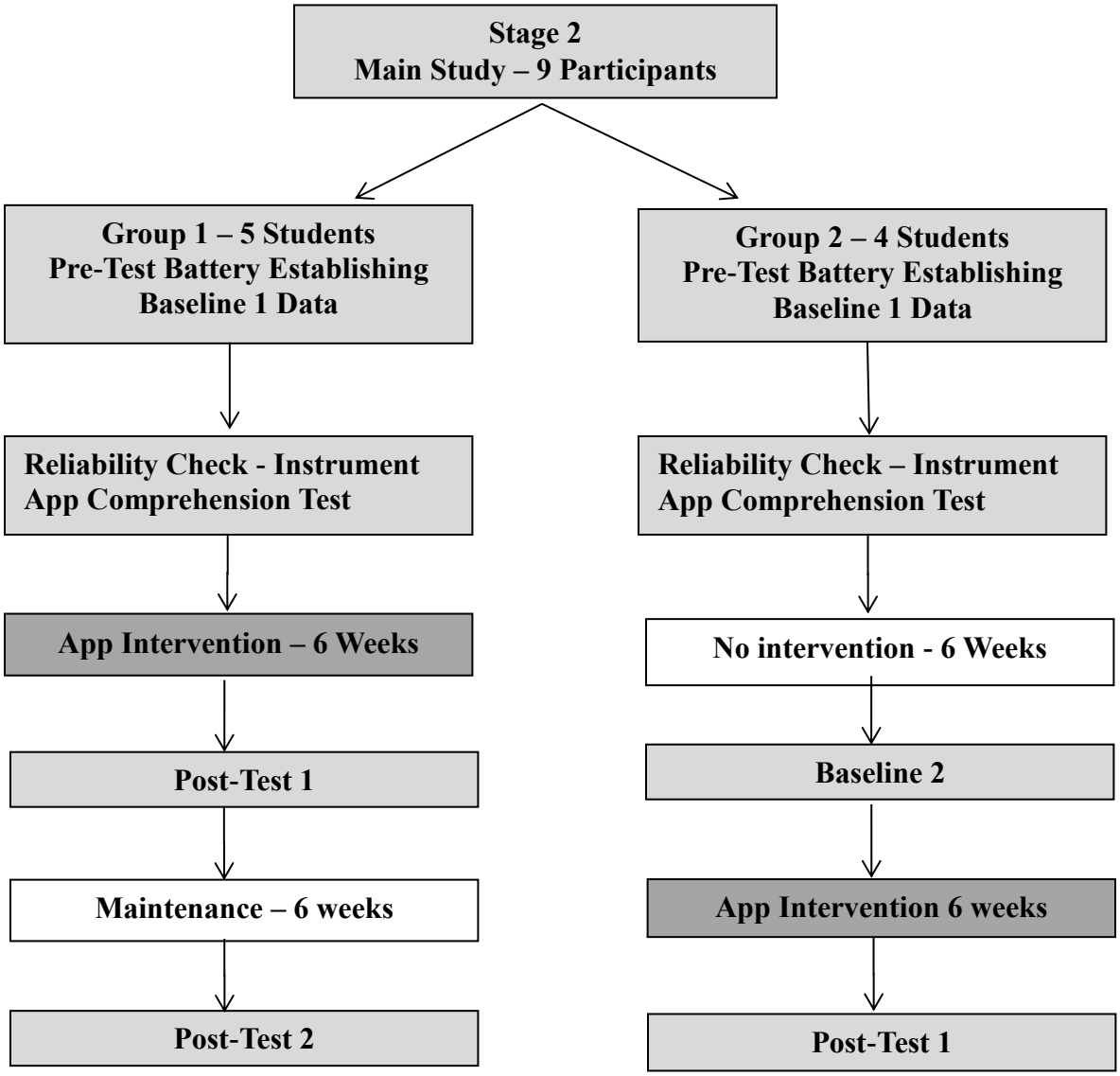

Figure 6-1 Main study: group process

6.2.1 Participants

Five male and four female participants identified as meeting the inclusionary criteria for study were recruited from Catholic Education Tasmania and the Department of Education Tasmania. These participants attended a number of different schools and were placed from Grade 2 through to Grade 6. One female participant moved from a Department of Education school and was home schooled for the second half of the study. This change was not associated with the intervention and did not impact upon her participation in the main study. Participants were identified through school records and professional assessments as students with HFASD. Their reading levels were varied; however, all participants could read independently as confirmed by their classroom teacher prior to commencing the study. Written consent was provided by the participants, parent/s, teachers and school principals before Baseline 1 data were collected.

6.2.2 Procedures

The main study was conducted across two school terms and involved a total of nine participants. At the beginning of the school term all nine participants (see *Figure 6-1)* were administered a pre-test battery consisting of the "Peabody Picture Vocabulary Test" Form A (PPVT-4; Dunn & Dunn, 2007) to collect Baseline 1 measurements of receptive vocabulary. This was followed with the "Expressive Vocabulary Test" Form A (EVT-2; Williams, 2007). The "Phonological Abilities Test" (PAT; Muter et al., 1997) was then used to ascertain if there were any phonological weaknesses which could contribute to comprehension deficits. A reading comprehension test, 'Lizards Love Eggs', recommended for Grade (year) 3 was provided from the "Tests of Reading Comprehension" (TORCH: 3; Mossensen et al., 2003) along with the App

Comprehension Test developed by the researcher. The Elementary Reading Attitude Survey (McKenna & Kear, 1990) was used to record participants' reading behaviours. The Elementary Reading Attitude Survey was administered only at Baseline 1. All tests were conducted by the researcher on an individual basis between 9.30am and 11.45am in a quiet room set aside for testing in each of the participants' school settings.

Two weeks later, the App Comprehension Test was repeated for all nine participants to determine reliability of the instrument (Harvill, 1991). After this test, participants were randomly assigned to two separate groups. Group 1 received an iPad loaded with the App intervention and participants in Group 2 were advised that they would receive the App intervention at the beginning of the following term. Teachers of the respective participants were provided with a check-list which allowed them to record information concerning the participants' frequency of use and any information that could possibly impact on their overall results, such as additional comprehension work (separate to the App intervention) with a teaching aide or teacher. This was to address the need to have all participants receive the same intervention even though they were located in different classroom contexts (Gersten et al., 2005).

The researcher returned in the final week of term and administered post-intervention tests to the five participants in Group 1 (Post-test 1), and the same test battery as an extended baseline test to the participants in Group 2 (Baseline 2). These tests consisted of the PPVT-4 Test Form B and the EVT-2 Test Form B. Reading comprehension levels were measured using the TORCH: 3 with the test "How Gorillas Communicate" recommended for Grade (year) 4 students, and again with the App Comprehension Test. The researcher recorded information from the participants in

Group 1 who used the App, on when and how they used it and favourite or least favourite features, as was previously recorded from participants in the pilot study.

After these tests were completed by the five participants in Group 1, the iPads were collected and the usage data from the App were downloaded and recorded. The iPads were then provided to the students in Group 2 at the beginning of the following term. Two participants from Group 2 did not receive these iPads until later into this term due to the school administration organisation. They were subsequently provided with sufficient time to work through the App in school hours and at home. These students are identified in the results profiles detailed later in this chapter.

In the final week of school term (six weeks later), the researcher returned after the Group 2 participants had completed the App intervention and administered the post-intervention tests (Post-test 1). Group 1 participants received the same tests as the Group 2 participants to ascertain if gains made by these students after using the App intervention the previous term were retained (Post-test 2). This consisted of the PPVT-4 Test Form A and the EVT-2 Test Form A, TORCH: 3 with the test "Rock Pools", recommended for Grade (year) 4 students, and App Comprehension Test. Information sheets were collected from respective the participants' teachers and the researcher noted and recorded how each participant used the App and what they liked or disliked. The data were then downloaded and recorded for each Group 2 participant.

6.3 Data Analysis

The participants' quantitative data were individually collated, graphed and reviewed. This provided a more complete picture that could highlight relationships between students'

receptive/expressive levels, phonological ability, and comprehension. Qualitative data in the form of observational notes, the reading attitude survey, and questions answered by participants, were collected by the researcher at testing times. The participants' teachers reported on any activities, illness or circumstances that would affect a participant's use of the App, and these were considered with their respective quantitative results. This allowed each participant's data set to be described and contextualised in relation to the effectiveness of the intervention, therefore, informing practice more effectively than one single method (Horner et al., 2005; Li et al., 2000). In the same way, the TORCH: 3 and the App comprehension test were analysed together as Gersten et al. (2005) considered that no measure is perfect and multiple measures should be used to assess the "important aspects of performance that an intervention might affect" (p. 158). The performance measures were selected from the review of literature (see *Chapter 2*) concerning the links between language, reading comprehension, and students with HFASD. The visual analysis that is provided in the current chapter on each participant's results interprets the level, trend, and variability of performance occurring during baseline and intervention conditions against their expressive/receptive and reading comprehension profiles. This type of analysis is recommended for single-subject research design to identify evidence-based practice in special education (Horner et al., 2005). Comprehension levels on the TORCH: 3 for the students were recorded in percentile and then normed to TORCH: 3 information. This involved converting each student's raw score into a TORCH: 3 percentile score and then into a TORCH: 3 normed score enabling the different TORCH reading pages to be converted to a common scale for comparison purposes. Changes on the students' TORCH: 3 normed scores were tracked over the study period against the raw scores taken from the App Comprehension Test.

6.4 Results

All participants' names have been replaced with pseudonyms to protect their privacy. The students' performance on the PPVT-4 (receptive language) and the EVT-2 (expressive language) remained stable over the course of the study period. This was not unexpected as these are more global measure of verbal ability. There are some interesting patterns in the Baseline 1 results that are worth noting in Table 6.1 below.

Table 6.1

Summary of Participants' Age and Standardised Test Performances at Baseline 1

Name	Age	Gender	PPVT Age Equivalence	EVT Age Equivalence	TORCH Age Percentile
*Nathan	7:8	M	7:3	7:10	6%
Gretel	8:1	F	9:1	10:3	60%
*Mark	8:2	M	7:10	6:5	7%
*Larry	9:0	M	6:3	5:7	3%
Abby	10:2	F	10:2	10:2	45%
Ken	10:6	M	11:6	16:11	61%
Jade	10:9	F	11:0	10:9	9%
Mack	11:8	M	9:7	9:0	6%
*Hanna	11:9	F	9:6	9:9	6%

*Participants who made the greatest gains post intervention.

The students' expressive and receptive language showed similar verbal ability trends, with both the PPVT-4 and the EVT-2 scores at a similar level of performance. The relationship between these two verbal ability test scores is highly correlated and at the $r = 0.89$ level.

In terms of students' verbal ability and their reading comprehension ability, there is also a positive correlation. The EVT-2 is correlated with the TORCH: 3 at a level of 0.72, and the PPVT-4 showed a correlation with the TORCH: 3 at a level of 0.54. That is, on average for this cohort of students, when their verbal ability is high then their corresponding TORCH: 3 percentile is also higher (see students: Gretel, Abby, and Jade), and if their verbal ability is lower, then their corresponding TORCH: 3 percentile score is also lower (see students: Mark, Mack, Hanna, and Larry).

Table 6.2

Pearson Correlation between expressive/receptive vocabulary and TORCH: 3 Comprehension

		PPVT	EVT	TORCH
PPVT	Pearson Correlation	1	.892**	.540
	Sig. (2-tailed)		.001	.134
	N	9	9	9
EVT	Pearson Correlation	.892**	1	.716*
	Sig. (2-tailed)	.001		.030
	N	9	9	9
TORCH	Pearson Correlation	.540	.716*	1
	Sig. (2-tailed)	.134	.030	
	N	9	9	9

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Of the cohort of nine students with HFASD, there were only two who achieved above the 50th percentile point on the TORCH: 3 test. The 50th percentile is the halfway point on the norming sampling of Australian students, with half the norming students achieving above this percentile point and half achieving below this point. Six of the nine students score in the lowest 10th percentile zone on the TORCH: 3 comprehension test, and none of the students scored in the top 25th percentile score, that is above the 75th percentile point on the TORCH: 3. These results support previous research that associates students with HFASD with difficulties in reading comprehension (Nation et al., 2006).

Post-Intervention Findings

Participants who were measured consistently with low to average levels of expressive and receptive vocabulary made the greatest gains in both the TORCH: 3 and the App comprehension test post-intervention (Nathan, Mark, Larry and Hanna). The nine participating students can also be divided into students who, on the embedded App questions, were having difficulty with these questions as shown by their higher error rates downloaded from the App intervention (App data are represented in each participant's profile later in this chapter). Higher error rates suggest that the students often needed to repeat the embedded questions and re-read and/or reflect on the passage of text to try to gain the correct response. These students are identified in Tables 6.3 and 6.4 as having high error rates for the embedded questions. This group is predominantly represented again by the students Nathan, Mark, Larry, and Hanna. These readers showed similar improvements on both the App comprehension test and the TORCH: 3 post-intervention. Abby was the other student from this group who showed improvements on the App

comprehension test but not on the TORCH: 3. Maintenance data at Post-test 2 were not available for Abby as she missed most of her schooling in the following term due to illness. One student, Ken, showed a drop in his TORCH: 3 comprehension level in extended Baseline 2 tests (between Baseline 1 and Baseline 2). This result reverted to his original Baseline 1 level in post-intervention testing (Post-test 1) after receiving the intervention. As a result, there was minimal change between his comprehension levels on the App comprehension test and the TORCH: 3 between his initial Baseline 1 measurements and his final post-intervention levels at Post-test 1.

Table 6.3

Pre and post intervention measures of the students' performance on App and TORCH test

Name	Error rate of embedded questions	App Comprehension Test			TORCH-score		
		Pre score	Post-score	Change	Pre	Post	Change
Hanna	high	10	17	+7	31	43	+12
Larry	high	0	3	+3	5	20	+15
Nathan	high	3	8	+5	15	33	+18
Mark	high	0	5	+5	0	20	+20
Abby	low	11	16	+5	36	35	+1
Ken	low	20	21	+1	40	50	+10
Jade	low	11	12	+1	40	42	+2
Gretel	low	8	9	+1	37	41	+4
Mark	low	8	8	0	26	28	+2

Data that were downloaded from the App reporting system have been converted to percentile (see Table 6.4). These data show error rates across the four embedded strategies (anaphor, literal, inference, and sequence) and they are performance based and summative in nature. When these data are compared against the baseline data of the TORCH: 3 and App comprehension tests, they affirm the participants' level of comprehension deficit. The following table shows the total number of embedded strategy within the App, and the error rate of each participant.

Table 6.4

Error rates reported in percentile downloaded as data from the App post-intervention

Participant	20 Anaphor	50 Literal	24 Inference	20 Sequence
*Hanna	15%	16%	33%	60%
*Larry	50%	40%	66%	65%
*Nathan	30%	34%	54%	60%
*Mark	50%	52%	29%	30%
*Abby	5%	15%	16%	35%
Ken	10%	10%	12%	15%
Jade	5%	8%	21%	10%
Gretel	0%	2%	0%	20%
Mack	0%	10%	4%	30%

*Participants with high error rates across most domains

The students who had less difficulty with the intervention as shown by the retrieved App data post-intervention on embedded questions (anaphors, literal comprehension, inferential comprehension and sequencing), were those students with little or no gains with either the TORCH: 3 or the App comprehension test. These students (Jade, Gretel, Mack, and Ken) also showed little or no change in their comprehension levels post-intervention. This is with the exception of Ken as explained earlier, who showed a decrease in comprehension on the TORCH: 3 whilst not participating in the intervention and a return to Baseline 1 level post-intervention.

Individual profiles

The results of those participants who made gains in comprehension post-intervention will be described first, followed by those who made little or no gain. These data have been represented individually in order to show the effect, if any, of the intervention against each participant's profile (Gersten et al., 2005).

In each profile the PPVT-4 and EVT-2 data are represented by the Baseline 1 measurement for all students and as expected, there was little to no change in these global measures over the course of the study (Williams, 2007). As students ranged in age, the results of the PPVT-4 and EVT-2 are represented visually to easily identify ability level relative to age. The TORCH: 3 and the App comprehension test have been graphed to demonstrate the students' progress from: Baseline 1 measurements and Reliability of the App comprehension test, to the Post-test 1 for Group 1 and Baseline 2 test for Group 2; and the maintenance tests for Group 1 Post-test 2 and Post-test 1 for Group 2 (Gersten et al., 2005). The trend was that the students made little or no change between the Baseline 1 stage and Reliability check when no intervention

was occurring. These measures act as the within "group contrast or control" to the intervention outcomes. After these, the following measurement represents post-intervention levels for Group 1 students, and an extended Baseline measurement for Group 2 students. The final graph point shows the maintenance trajectory of any gains made post-intervention for Group 1 students, and the post-intervention measurements for Group 2. The data downloaded from the App after each participant completed the intervention is also represented to show each student's comprehension profile and their area/s of deficit recorded as an error rate across each embedded strategy. The individual information pertaining to each of the nine participants is reported below.

Participant Hanna

Hanna was aged 11 years and 9 months at the time she commenced the study and attended a mainstream primary school enrolled in Year 6. Hanna was very shy and withdrawn at times and indicated that she enjoyed reading at home and preferred to read rather than watch television. Her teacher reported that she would not participate in reading sessions in class or taking reading tests at school which was confirmed through the Reading Attitude Survey (McKenna & Kear, 1990). Hanna's results from the Phonological Awareness Test showed no indication of any phonological deficits as her results were at ceiling level on all of the sub-tests.

Hanna's receptive and expressive vocabulary levels when compared to her chronological age, were almost one standard deviation below the mean when collected as Baseline 1 data at the commencement of the study. These levels remained consistent over the study period with no significant variations in these levels in Post-test 1 and Post-test 2.

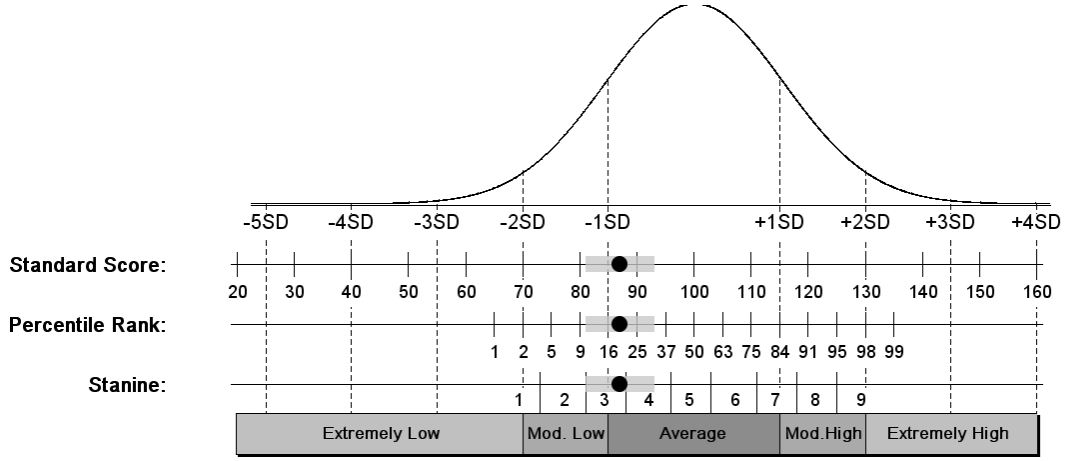

Figure 6-2 PPVT-4 Hanna Baseline 1

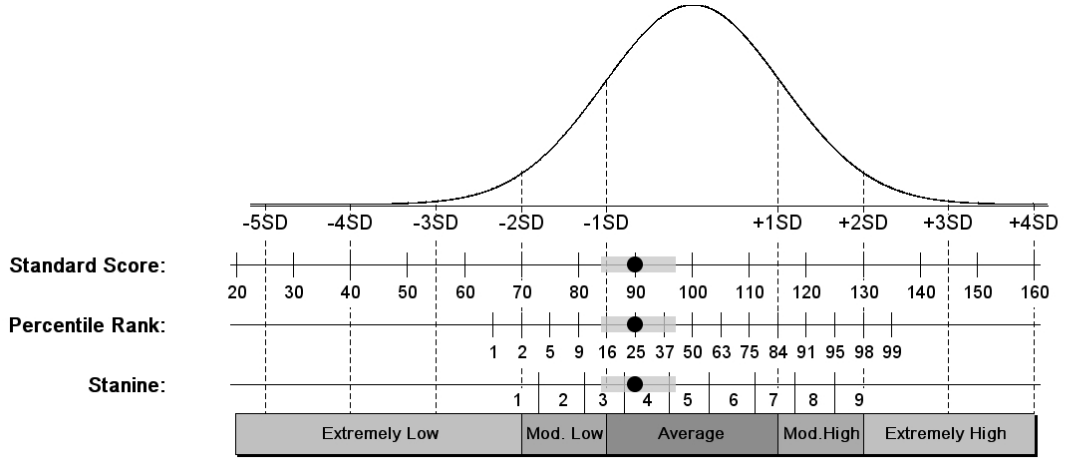

Figure 6-3 EVT-2 Hanna Baseline 1

Hanna's comprehension levels as measured by the TORCH: 3 were below average and were recorded at Year 3 level. She scored 9 out of 24 on her initial App Comprehension Test. Hanna made similar gains in both the TORCH: 3 and App Comprehension Test after completing the App intervention between the 11th August and the 22nd September (see *Figure 6-4)*. These gains were not maintained between Post-test 1 and Post-test 2 when she was not using the App.

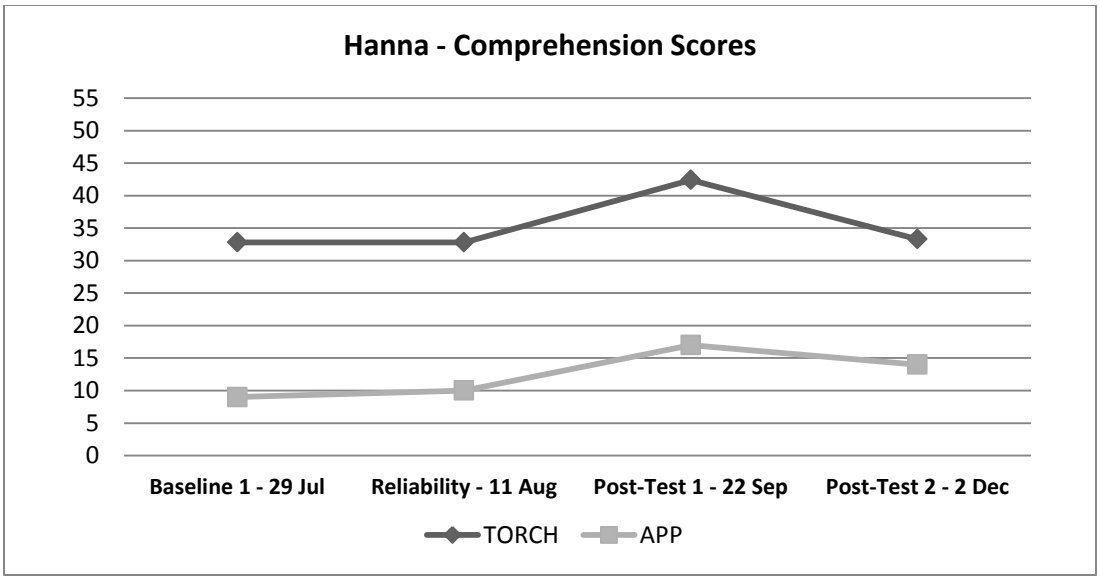

Figure 6-4 Comprehension Tests TORCH: 3 and App Comprehension Test

Hanna reported that she read the text in the App and did not listen to the audio. She also mentioned that she preferred to read this way in her own time. Hanna said that while she was using the App, she noticed that she was going back and re-reading passages more frequently and automatically to check for comprehension than when reading general texts in school. Hanna's errors retrieved from the App Data showed errors across all areas with more demonstrated in her sequencing ability.

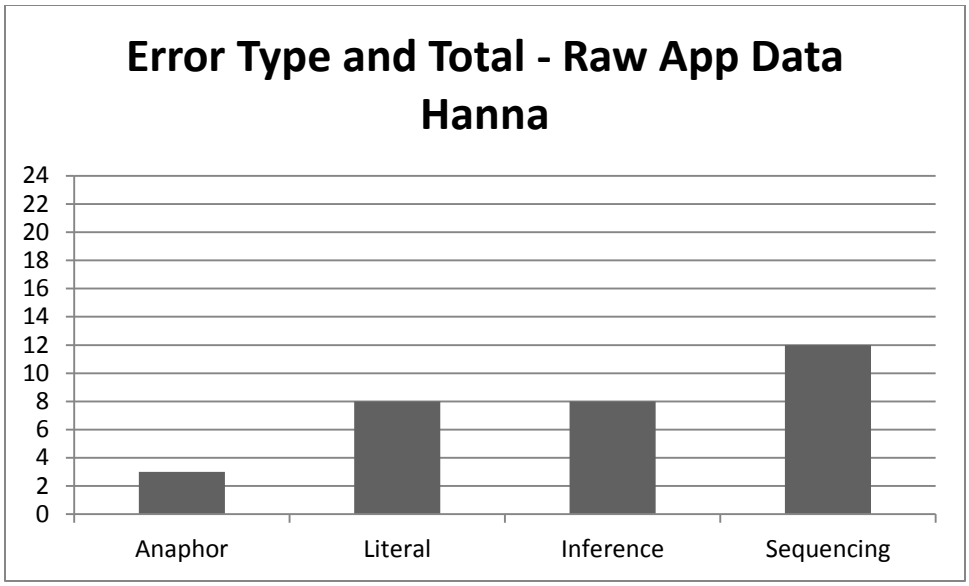

Figure 6-5 Downloaded data retrieved from App Intervention – Hanna

Participant Larry

Larry was aged 9 years at the time he commenced the study. Larry attended a mainstream primary school and was enrolled in Year 3. Larry was a very quiet student who indicated that he enjoyed reading at home and preferred to read rather than play. His teacher reported that Larry enjoyed participating in reading sessions in class and did not mind taking reading tests at school. He described Larry's comprehension as highly impaired. Larry indicated he enjoyed reading all types of texts such as story picture books, comics, magazines, and newspapers but did not like chapter books. His results from the Phonological Awareness Test showed no indication of any phonological deficits as these were at ceiling level on all of the sub-tests.

Larry's receptive and expressive vocabulary levels were extremely low at almost minus two standard deviations below the mean in comparison to his chronological age. These data were collected at Baseline 1 on commencement of the study. Both PPVT-4 and EVT-2 levels remained consistent over the study period with no significant variations in these levels in Post-test 1 and Post-test 2.

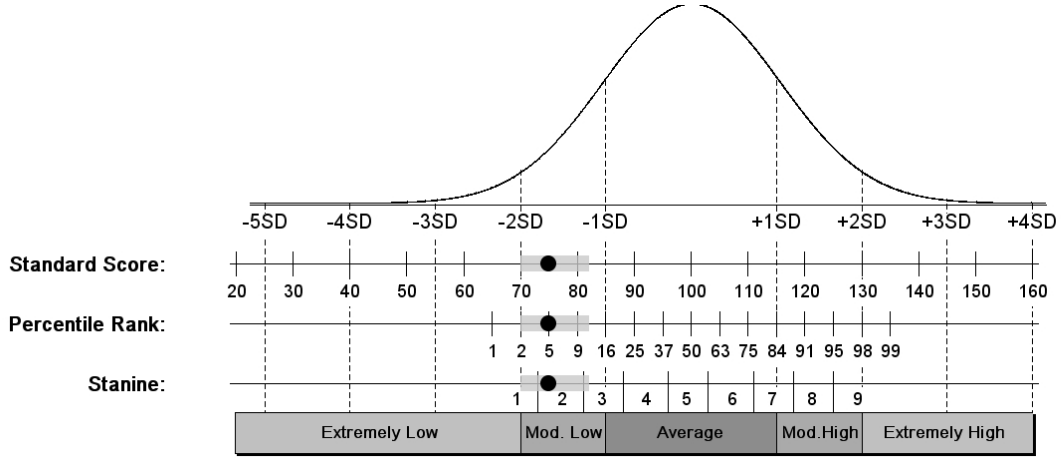

Figure 6-6 PPVT-4 Larry Baseline 1

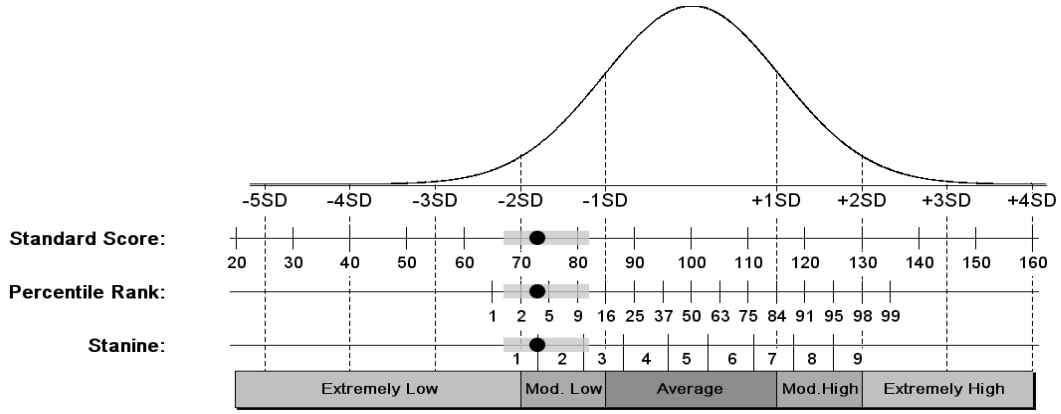

Figure 6-7 EVT-2 Larry Baseline 1

Larry's comprehension levels, as measured by the TORCH: 3, were well below average at Year 3 level and he scored 0 out of 24 on the initial App Comprehension Test. Larry's profile shows similar gains in both the TORCH: 3 and App comprehension test after completing the App intervention between the 12th August and the 24th September (see *Figure 6-8)*. These gains were not maintained and reduced over the period between Post-test 1 and Post-test 2 when he was not using the App.

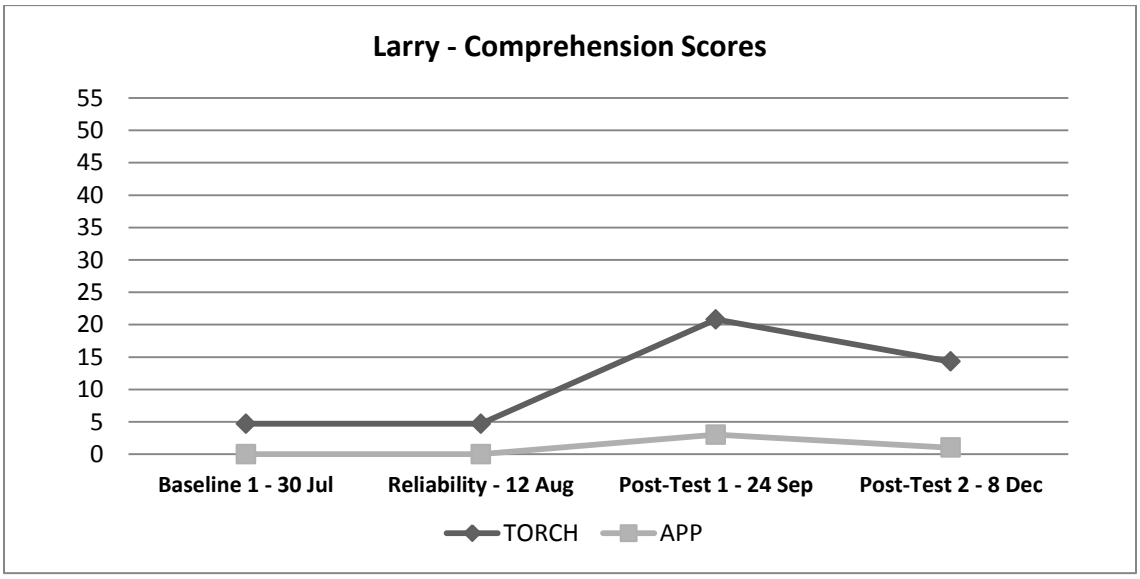

Figure 6-8 Comprehension Tests TORCH: 3 and App Comprehension Test

After completing the App intervention at Post-test 1, it was noted by the researcher that Larry was reading more fluently and was independently following the words with a pencil as he read. When it came time to answer the comprehension questions on the TORCH: 3 and App comprehension test, Larry was referring back to the passage of text to look for answers within

the text which was not noted at Baseline 1 data collection. When Larry was reading aloud from the App comprehension test passage, he came to a passage of direct speech. *"Well, well, I wonder what happened to this fellow," said Farmer Brown, poking Billy with his toe* which Larry read with prosody. He turned to the researcher and explained, *"I like this bit!"* and continued to read the next two sentences with prosodic expression. *"Ah ha!" shouted Farmer Brown happily. "So this is the thief who has been stealing my eggs!"* Larry had not previously demonstrated prosody whilst reading which was confirmed by his teacher. After questioning Larry further regarding how he used the App, he explained that he had listened with headphones and read along with the text. Larry's data retrieved from the App showed a high number of errors across all areas measured, with the highest in sourcing literal and inferential information from text.

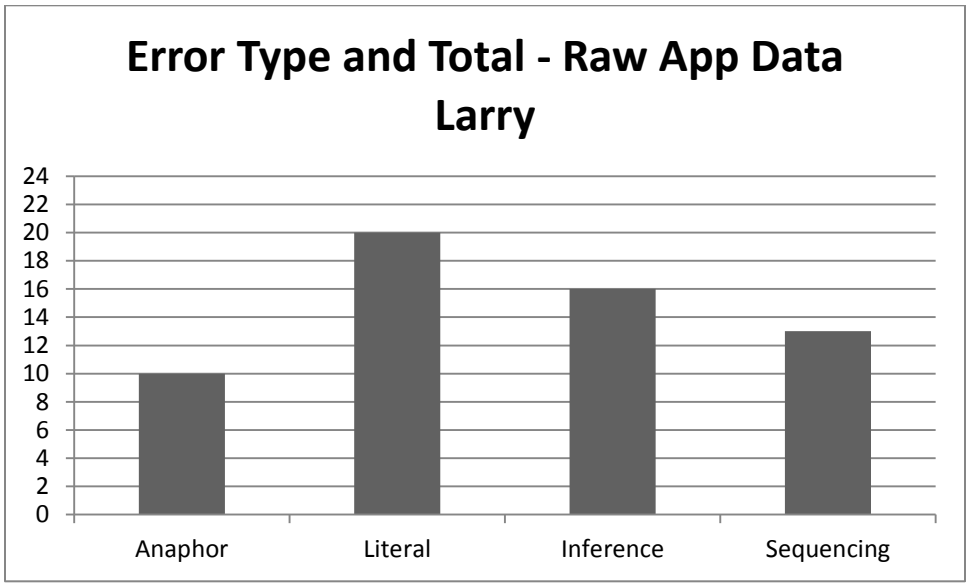

Figure 6-9 Downloaded data retrieved from App Intervention – Larry

Participant Nathan

Nathan was aged 7 years and 8 months at the time he commenced the study, attended a mainstream primary school, and was enrolled in Year 2. Nathan was a very outgoing student who enjoyed discussions on many topics. Nathan also had a diagnosis of Attention Deficit Hyperactivity Disorder (ADHD). Nathan indicated that he enjoyed reading at home and at school and loved reading on an iPad. His teacher reported that he was prone to regular outbursts in the classroom and had difficulties settling into tasks and maintaining concentration. Nathan remarked that he did not enjoy participating in reading sessions in class and did not have any issues with taking reading tests at school. Nathan's teacher explained that his comprehension was highly impaired and that she had great difficulty keeping him focused on his school work. He would regularly refuse to complete activities that he did not want to do. Nathan indicated that he enjoyed reading chapter books, information books, comics and electronic books through the Reading Attitude Survey (McKenna & Kear, 1990). His results from the Phonological Awareness test showed he made 3 errors on the Phoneme Deletion Sub-test in the identification of end sounds in words.

Nathan's receptive and expressive vocabulary levels were at average for his chronological age when collected at Baseline 1 on commencement of the study. These levels remained consistent over the study period with no significant variations in these levels measured in Post-test 1 and Post-test 2.

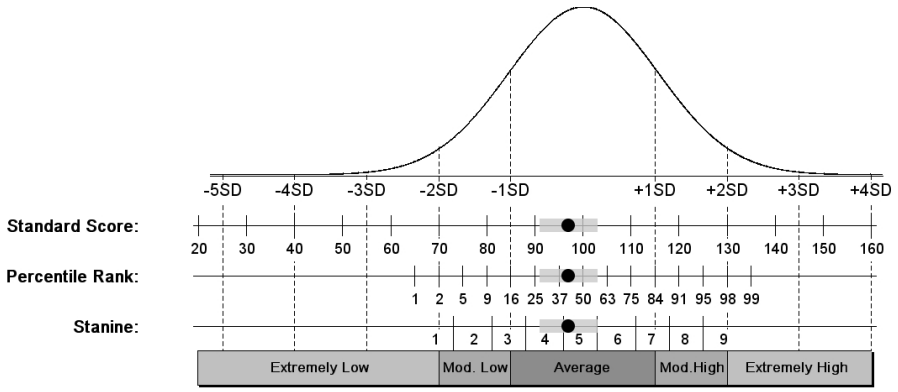

Figure 6-10 PPVT-4 Nathan Baseline 1

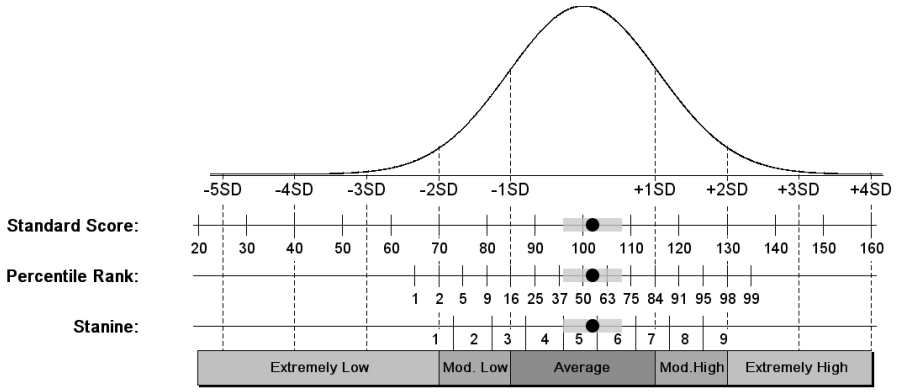

Figure 6-11 EVT-2 Nathan Baseline 1

Nathan's comprehension levels as measured by the TORCH: 3 at 14.3 and were initially very low and well below Year 3 level, even as he was in Year 2 at the time. He scored 2 out of 24 on the initial App Comprehension Test. Nathan's profile shows similar gains in both the TORCH: 3 and App Comprehension Test after completing the App Intervention at Post-test 1 on the 25th September (see *Figure 6-12)*. These gains were maintained on the App Comprehension

Test over the period between Post-test 1 and Post-test 2 when he was not using the App. Even as all other data sets for Nathan were completed at Post-test 2, data from the TORCH: 3 were not able to be collected at the completion of the study as Nathan ceased attending school just prior to the end of the school term before his TORCH: 3 test could be administered.

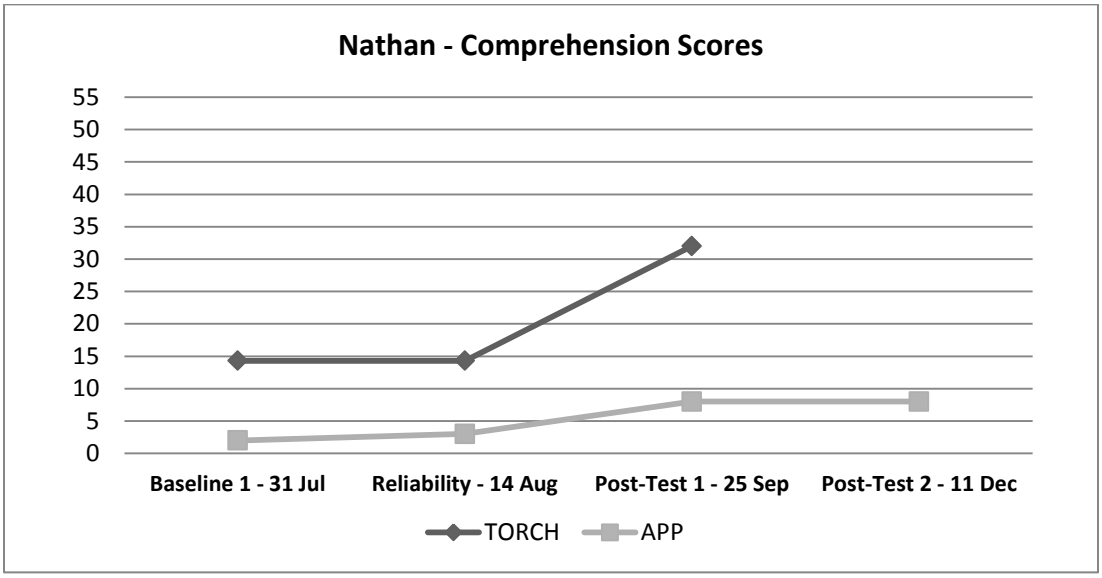

Figure 6-12 Comprehension Tests TORCH: 3 and App Comprehension Test

After completion of the intervention, observation notes taken by the researcher show that Nathan was reading more fluently with fewer errors. There was a significant improvement in his reading as reported in the check-list notes recorded by his teacher and classroom aide. Changes in his reading behaviour were seen in self-correcting and looking for information in the text when completing the TORCH:3 and App comprehension test. He commented that he really liked reading the App and particularly enjoyed the embedded picture builder activities. Nathan mentioned that he listened and read along with the text while using the App. On completion of

Post-test 2, Nathan was still reading with accuracy and showing improved fluency and continued to refer back to the text when he completed the App comprehension test. Data retrieved from the App intervention showed that Nathan had difficulties across all areas of comprehension; however, these were more noticeable in the areas of retrieving accurate literal and inferential information from text and sequencing.

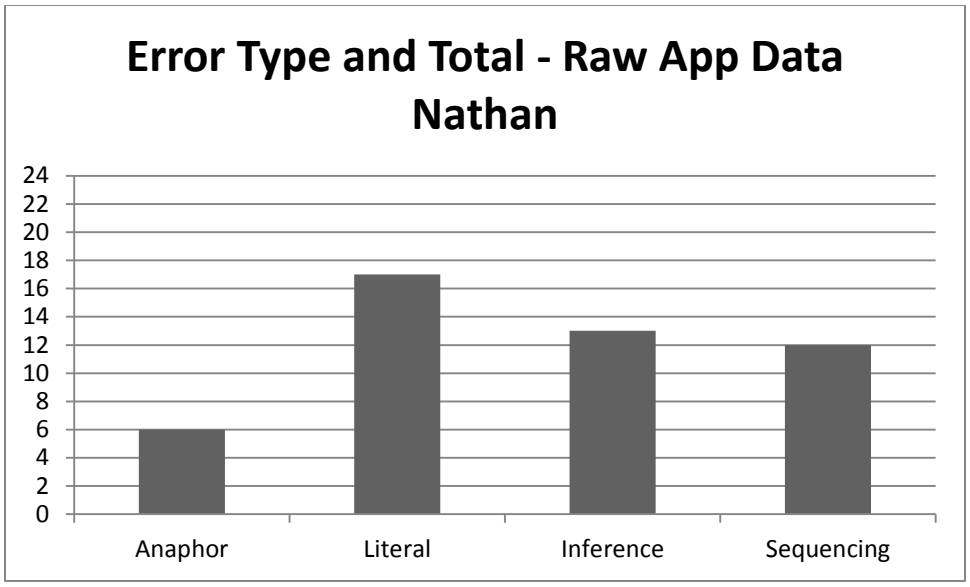

Figure 6-13 Downloaded data retrieved from App Intervention – Nathan.

Participant Mark

Mark was aged 8 years at the time he commenced the study and attended a mainstream primary school, enrolled in Year 3. Mark was a quiet student who had difficulties staying on task and as a result, worked regularly with an aide in class. He indicated that he enjoyed reading at home but not at school. His teacher reported that Mark did not want to participate in reading sessions in class and his considered his comprehension as highly impaired. Mark indicated that

he only liked to read story picture books. His results from the Phonological Awareness Test showed two errors in the Phoneme Deletion Test with beginning and end sounds.

Mark's receptive vocabulary was at an average level but his expressive vocabulary was moderately low at almost minus one standard deviation below the mean for his chronological age. Both these levels remained consistent over the study period with no significant variations in these levels in Post-test 1 and Post-test 2.

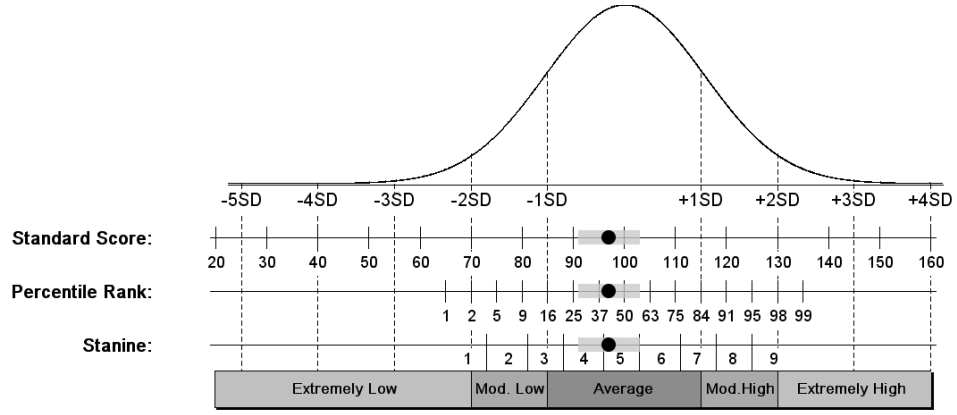

Figure 6-14 PPVT-4 Mark Baseline 1

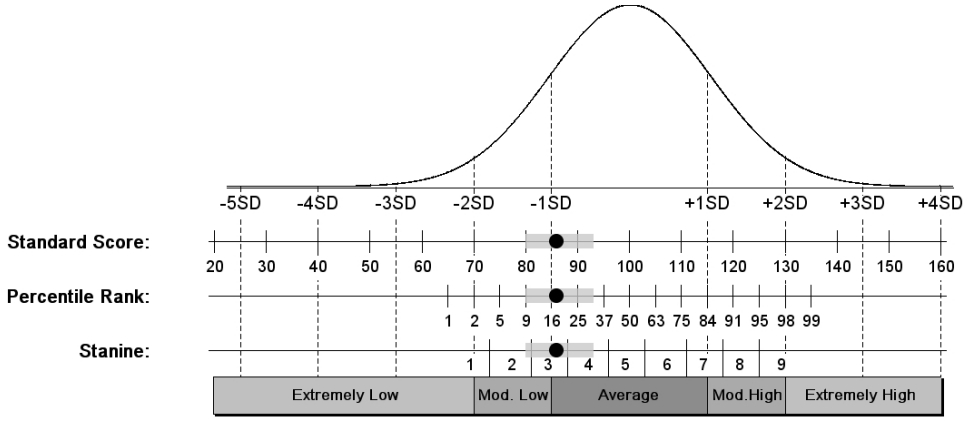

Figure 6-15 EVT-2 Mark Baseline 1

Mark's comprehension levels were measured by the TORCH: 3 initially at Nil, as he did not achieve a correct answer to any of the questions. He scored 0 out of 24 on the Baseline 1 App comprehension test. Mark's profile shows a correlation in gain for both the TORCH: 3 and App comprehension test after completing the App Intervention at Post-test 1 on the 24th September (see *Figure 6-16)*. These gains dropped away slightly over the period between Post-test 1 and Post-test 2 when he was not using the App.

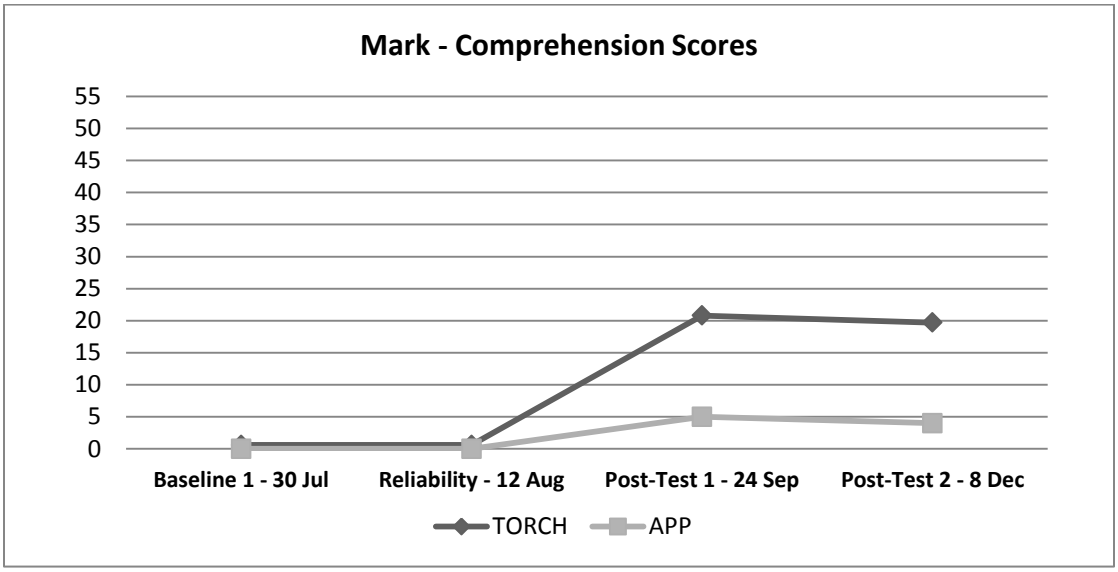

Figure 6-16 Comprehension Tests TORCH: 3 and App Comprehension Test

Prior to the intervention the observation notes made by the researcher show that Mark was not seeking answers from text when answering the comprehension questions. He appeared "to be reading the text and then trying to answer the questions by memory." Very detailed notes were provided from Mark's classroom aide. These notes show that when he began using the App he was enthusiastic but was skipping text and getting the answer incorrect. His aide reported that

she was not sure whether Mark actually understood the story and was still guessing answers in the second week. In week three, it was noted that he was using the audio and needed a reminder to read the passage before answering questions. By the end of this week it was noted that Mark was a lot more interested in using the App and tried to read the questions without guessing. Week four notes remark that Mark appeared to be rushing through but "seemed to understand it better today" however, the aide's notes mention that he continued to guess at answers. The notes from weeks five and six contain remarks that discuss improved levels of focus and listening and a desire by Mark "to do" more chapters. They also mention that Mark sometimes still guessed at the answers unless he was prompted to slow down and read the instructions. The final diary entry made by the aide in week six reports, "Good listening, got all answers right."

Data retrieved from the App confirm that Mark completed 17 of the 25 chapters of the intervention. The chapters were completed with encouragement from and in the presence of his teaching aide. This was due to Mark's difficulties in behaviour, concentration, and staying on task. Mark's teacher and teacher aide were instructed by the researcher prior to the intervention to not assist or prompt Mark when he was reading and answering questions from the App. They supported his intervention through keeping him on task. *Figure 6-17* below shows Mark's errors from data download from the App intervention after he completed 17 chapters.

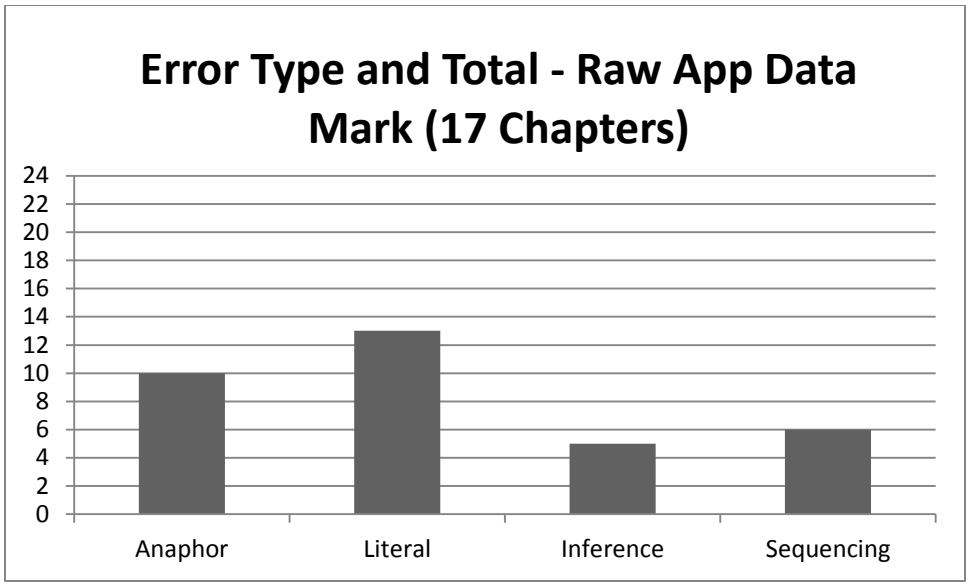

Figure 6-17 Downloaded data retrieved from App Intervention – Mark

Participant Abby

Abby was aged 10 years and 2 months at the time she commenced the study and attended a mainstream primary school enrolled in Year 4. Abby was not shy and spoke confidently about all aspects of her school work. Her teacher reported that she participated well in all classroom activities and was a valued member of the class. Abby indicated that she read very regularly and enjoyed reading at home. She reported that her preference was to read rather than watch television, and she enjoyed reading information books, comics and chapter books. Her teacher remarked that even as Abby was a very bright, keen, and enthusiastic student, he believed her comprehension was impaired and she tended to rush through work and activities, often taking extra work home when she was not required to do so. Abby's results from the Phonological Awareness test were at ceiling level on all of the sub-tests, showing no phonological deficits.

Abby's receptive and expressive vocabulary levels were at average for her chronological age when collected as Baseline 1 data at the commencement of the study. These levels remained consistent over the intervention period with no significant variations in these levels in Post-test 1 for the PPVT-4 Form B and EVT-2 Form B. Abby was not able to complete Post-test 2 as she was hospitalised for a number of weeks due to an undisclosed illness and repeated medical assessments. Over this time she was not regularly in attendance at school.

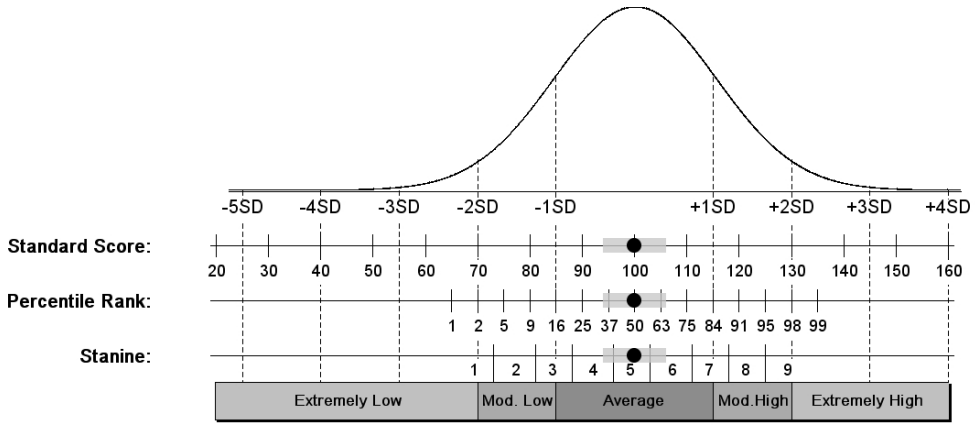

Figure 6-18 PPVT-4 Abby Baseline 1

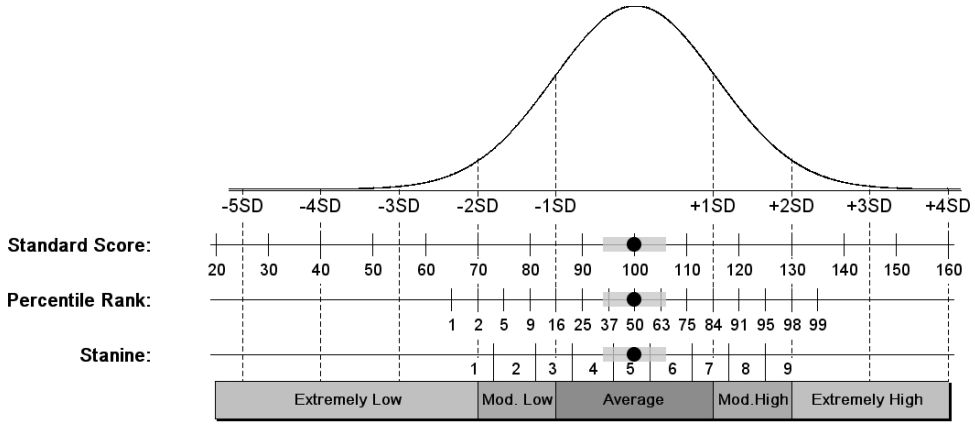

Figure 6-19 EVT-2 Abby Baseline 1

Abby's comprehension levels as measured by the TORCH: 3 were at mean average for her Year 4 level. She scored 10 out of 24 on the initial App comprehension test. Abby's profile shows inconsistent comprehension results with a slight decrease in levels recorded by the TORCH: 3 and a gain from the App comprehension test after completing the App intervention on the 22nd September (see *Figure 6-20)*. It was not possible to track performance between Post-test 1 and Post-test 2 as Abby was not regularly attending school due to ongoing illness.

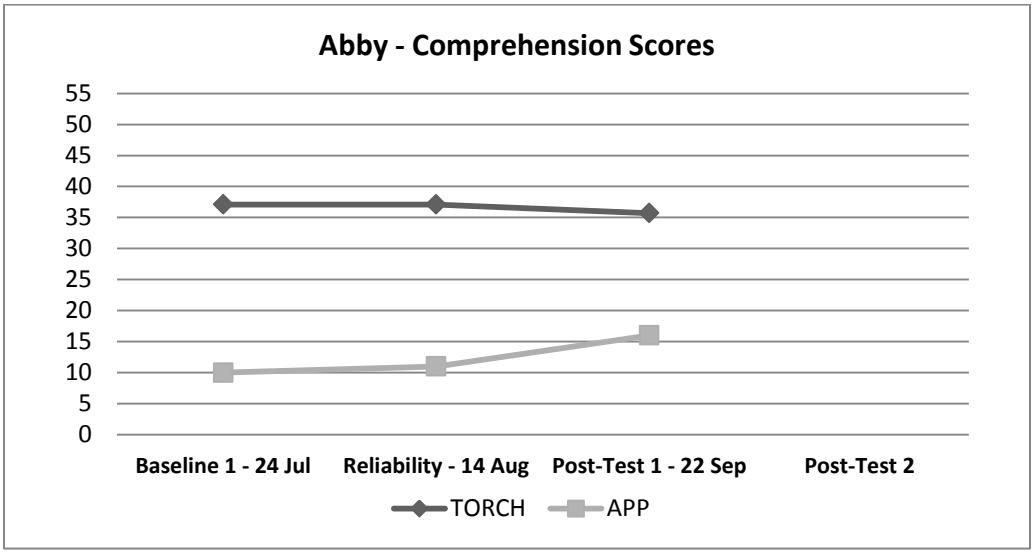

Figure 6-20 Comprehension Tests TORCH: 3 and App Comprehension Test

After completing the App intervention, Abby described how she really enjoyed using the App and did not listen to the audio. Data retrieved from the App show that Abby had more difficulty with her sequencing skills than in other areas of comprehension performance although these error rates were relatively low.

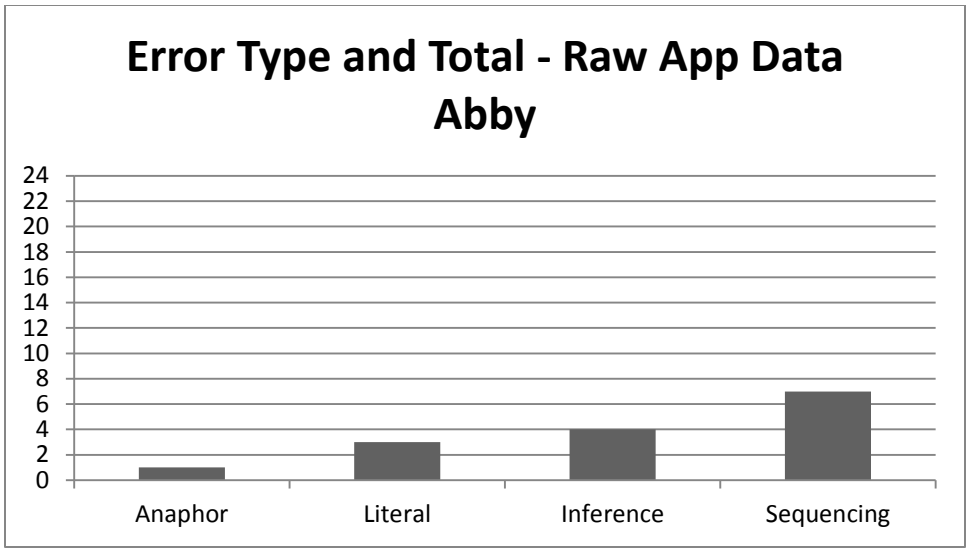

Figure 6-21 Downloaded data retrieved from App Intervention – Abby

Participant Ken

Ken was aged 10 years and 6 months at the time he commenced the study. He attended a mainstream primary school and was enrolled in Year 4. Ken's brother Larry was also part of the main study enrolled in Year 3 (see previous details for comparison). Ken was a bright and communicative student who demonstrated frequent perseverative behaviours. His teacher reported that Ken excelled in literacy activities but was not as competent in mathematics. Ken reported that he enjoyed reading in class and did not mind taking reading tests at school. Ken's teacher described his comprehension level as excellent. On the reading attitude survey, Ken indicated that he enjoyed reading most types of texts such as story picture books, comics, chapter books, and electronic books but did not like reading information books, magazines or newspapers. His results from the Phonological Awareness Test showed no indication of any phonological deficits as these were at ceiling level on all of the sub-tests.

Ken's receptive vocabulary levels were measured at just above average for his chronological age. There was almost one standard deviation between his receptive and expressive vocabulary levels. Expressive vocabulary was measured at one and a half standard deviation points above average his age mean. Ken's expressive vocabulary data show his operational result at just under adult level. These data were collected at Baseline 1 on commencement of the study. Both PPVT-4 and EVT-2 levels remained consistent over the study period with no significant variations in these levels in Baseline 1 and Post-test 1.

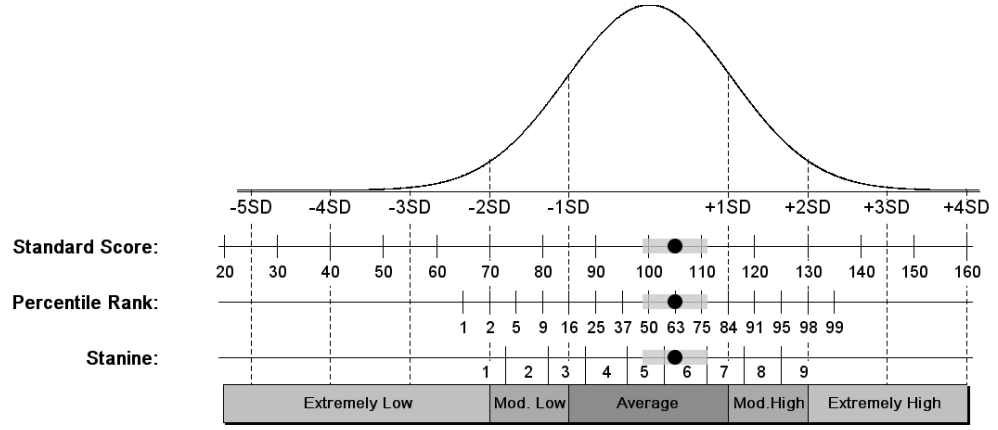

Figure 6-22 PPVT-4 Ken Baseline 1

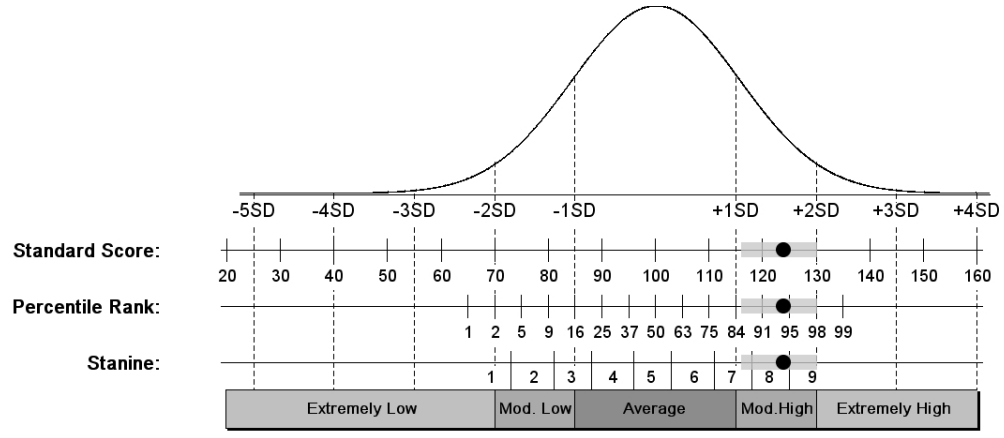

Figure 6-23 EVT-2 Ken Baseline 1

Ken's Baseline 1 comprehension level of 48.1, as measured by the TORCH: 3, was above mean average of 38.1 for his Year 4 level. He scored 19 out of 24 on the initial App comprehension test. Ken's profile shows a small decrease in comprehension results to just above average between Baseline 1 measurement and Baseline 2, and little gain in the App comprehension test result. On completion of the App intervention between Baseline 2 and Post-test 1, Ken's TORCH: 3 levels were recorded at similar to Baseline 1 measurements (see *Figure 6-24)*. Results for the App comprehension test show little change from Baseline 1 measurement of 19 to the Post-test 1 measurement of 21.

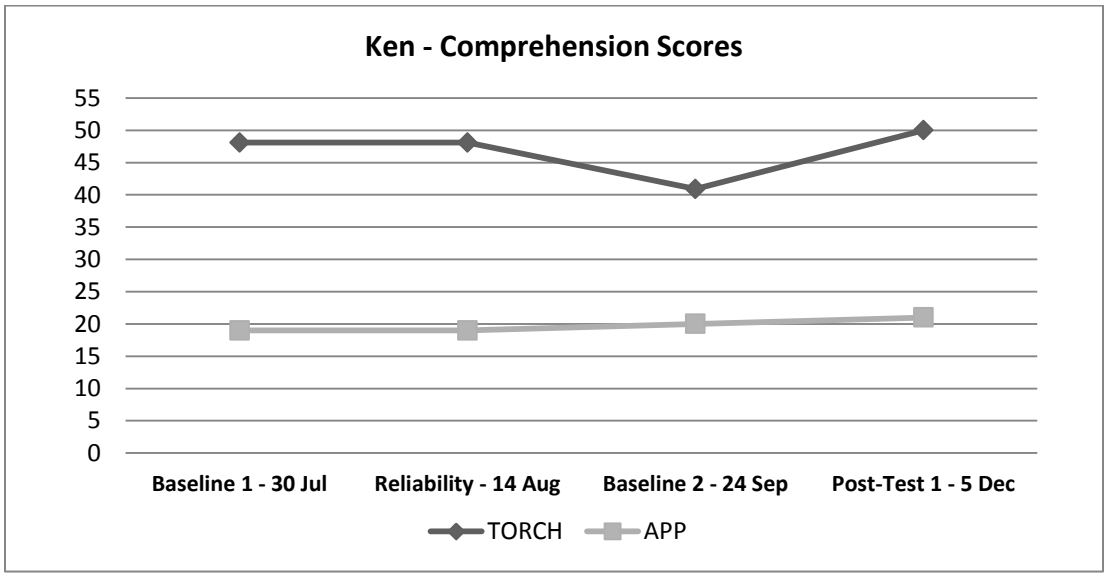

Figure 6-24 Comprehension Tests TORCH: 3 and App Comprehension Test

The researcher noted when testing Ken that he read very fluently with prosody. When he answered questions for the comprehension tests, he consistently went back to the text to find the

answer. Data download from the App show that Ken made few errors when using the App, with low errors recorded across all four fields (see *Figure 6-25)*.

Ken explained that he had really enjoyed reading the App and was interested in the story. When the researcher explained that the story in the App had been adapted from an original written one hundred years prior, he expressed interest in reading the original story. The researcher provided the original publication to his classroom teacher so that he could read the original version in class the following term.

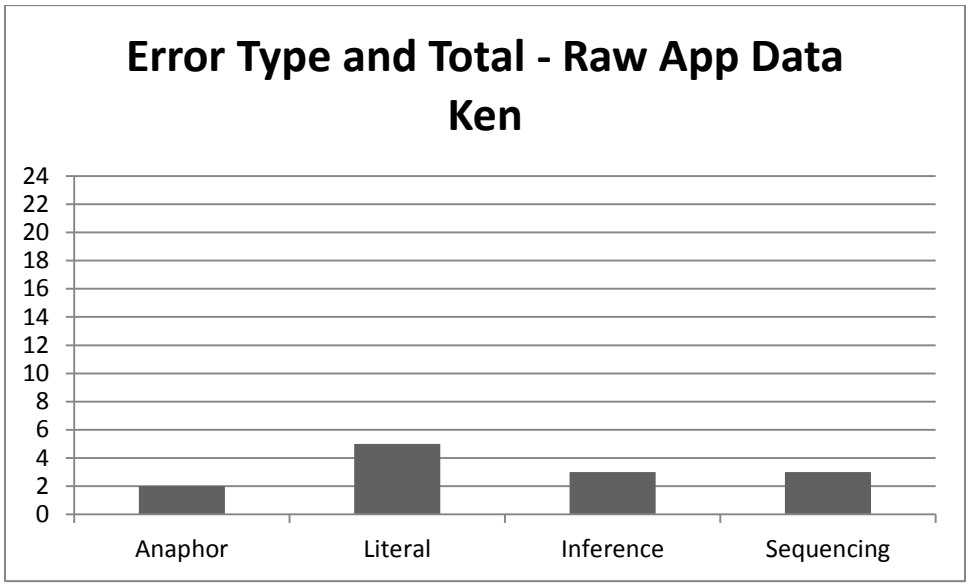

Figure 6-25 Downloaded data retrieved from App Intervention – Ken

Participant Jade

Jade was aged 10 years and 9 months at the time she commenced the study and attended a mainstream primary school, enrolled in Year 5. After the completion of term at Baseline 2, Jade was removed from school to be home schooled by her mother for the following term. Jade

was a quiet student but communicated well. Her classroom teacher reported that although she participated consistently in all classroom activities, Jade was beginning to have some difficulties with the social aspects of schooling such as friendships. Jade indicated that although she liked to read at home, she preferred to watch television or play. Her reading attitude survey showed that she did not like to answer questions about her reading in class, read aloud, do worksheets, or read at school. Jade recorded that she did not mind doing reading tests. Her favourite texts were story picture books and comics and she did not like reading information books or newspapers. Jade's results from the Phonological Awareness Test were at ceiling level on all of the sub-tests, showing no phonological deficits.

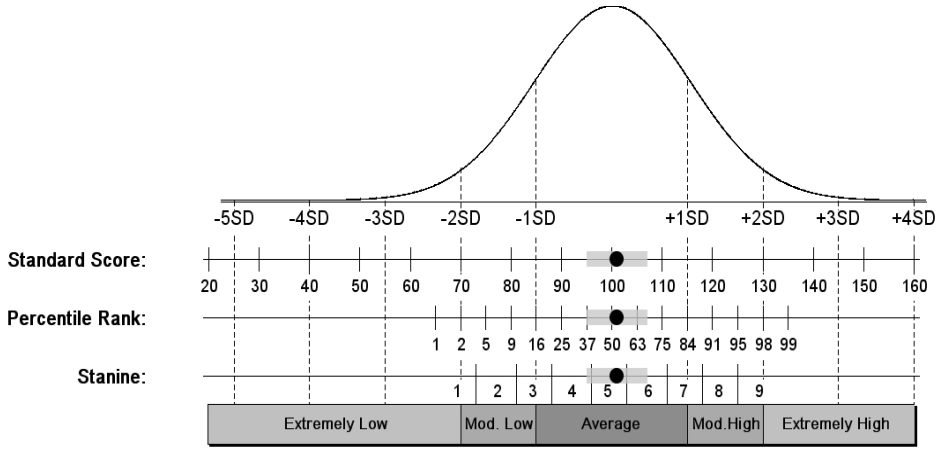

Figure 6-26 PPVT-4 Jade Baseline 1

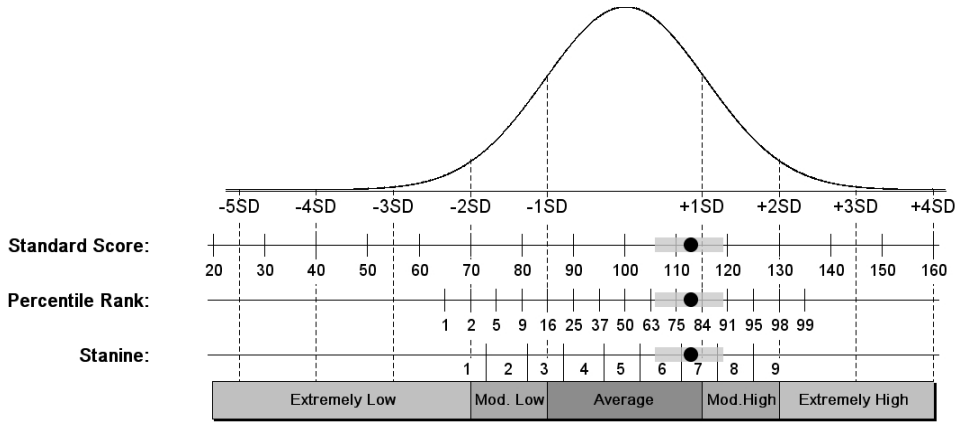

Figure 6-27 EVT-2 Jade Baseline 1

Jade's receptive vocabulary levels were consistently measured at just above average for her chronological age and her expressive vocabulary was measured at almost one standard deviation point above average. This vocabulary profile was similar to participant Ken's.

Jade's Baseline 1 comprehension level of 31.8, as measured by the TORCH: 3, was below the mean average of 43.8 for her Year 5 level. She scored 12 out of 24 on the initial App comprehension test. Jade's profile shows an increase in comprehension results as measured by the TORCH: 3, from 31.8 to 40 while she was not participating in the intervention between Baseline 1 and Baseline 2. A minor gain was shown on the TORCH: 3 (from 40 to 42) after using the intervention, between Baseline 2 and Post-test 1. Results of the App comprehension test remained reasonably constant over both periods of testing.

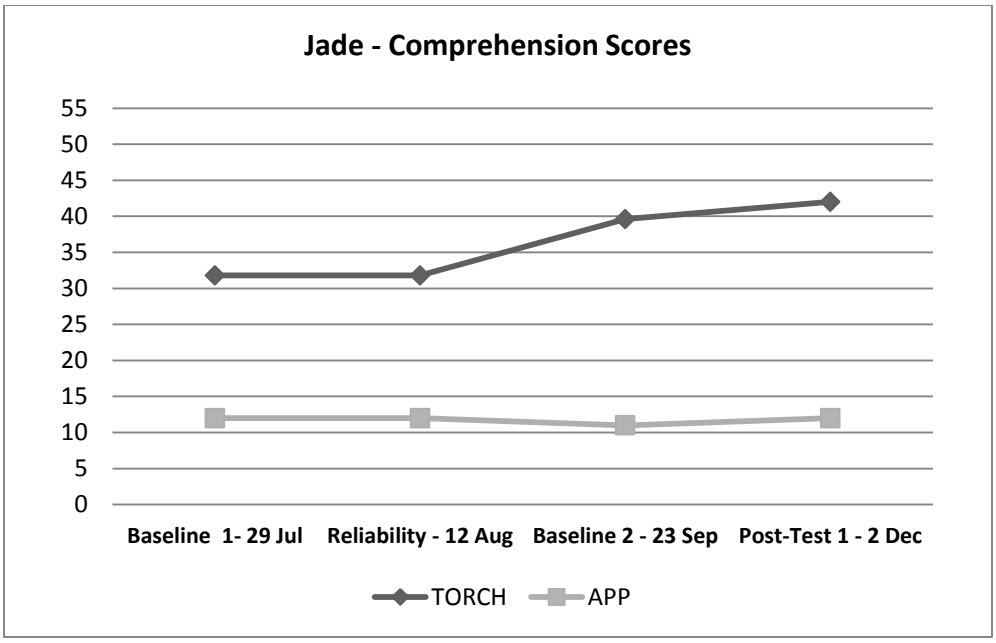

Figure 6-28 Comprehension Tests TORCH: 3 and App Comprehension Test

Jade described how she really enjoyed reading the App and that she did not listen to the audio. The researcher noted that she read very fluently with prosodic emphasis. At Post-test 1 she described how she was enjoying home schooling a lot more than being in class, and she had lots of friends she socialised with who also did not attend mainstream schooling. Jade's results downloaded from the App showed that she made few errors overall (see *Figure 6-29)*, the majority in seeking literal or inferential information from text. This profile was also similar to participant Ken's.

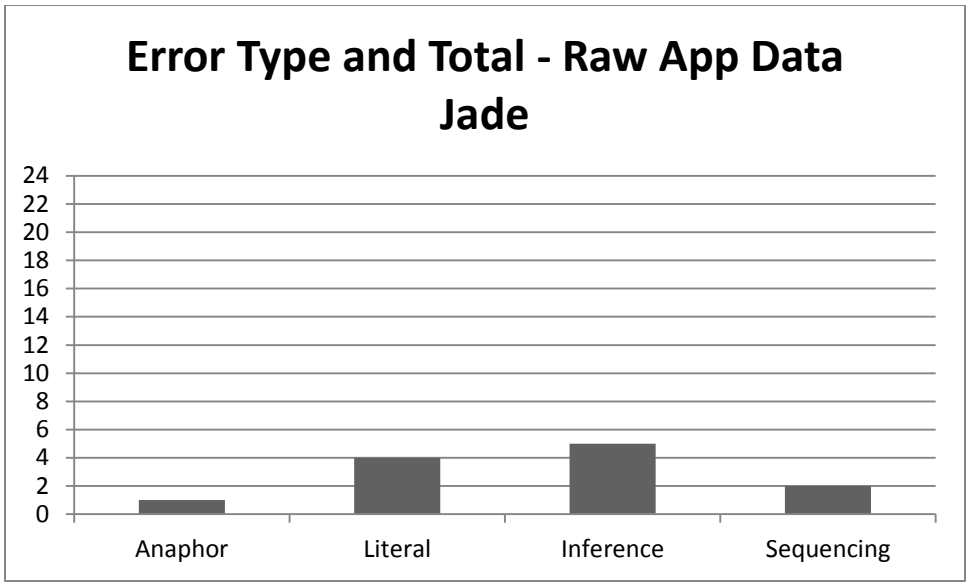

Figure 6-29 Downloaded data retrieved from App Intervention – Jade

Participant Gretel

Gretel was aged 8 years and 1 month at the time she commenced the study and attended a mainstream primary school, enrolled in Year 2. Gretel was a bright and chatty student, who was quite confident in conversation. Her teacher reported that Gretel was 'an excellent student' who participated well in all classroom activities. Gretel used the App intervention for three of the six weeks allocated for the intervention due to school administrative difficulties. Gretel indicated that although she liked to read at home a lot and enjoys reading aloud in class, she did use the dictionary. Her reading attitude survey shows that she enjoyed answering questions about her reading in class and having a reading test. Her favourite texts were story picture books, chapter books, and magazines. Gretel's results from the Phonological Awareness Test were at ceiling level on all of the sub-tests, showing no phonological deficits. Gretel's receptive vocabulary

levels were consistently measured around moderately high for her chronological age and her expressive measurement at one standard deviation point above average.

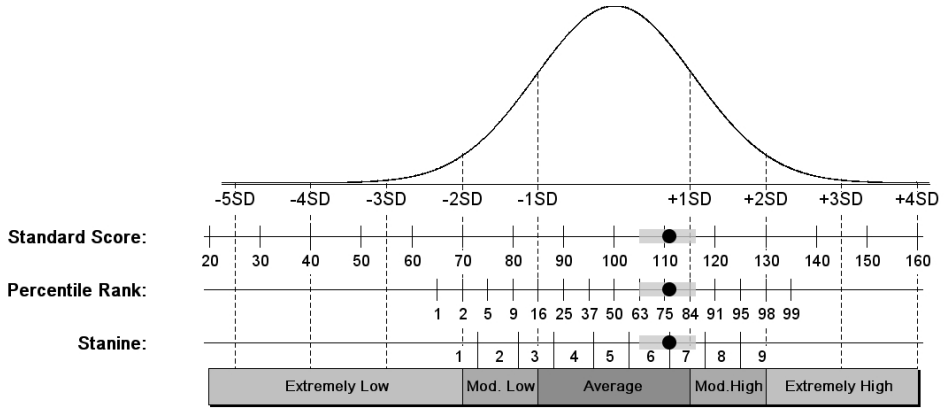

Figure 6-30 PPVT-4 Gretel Baseline 1

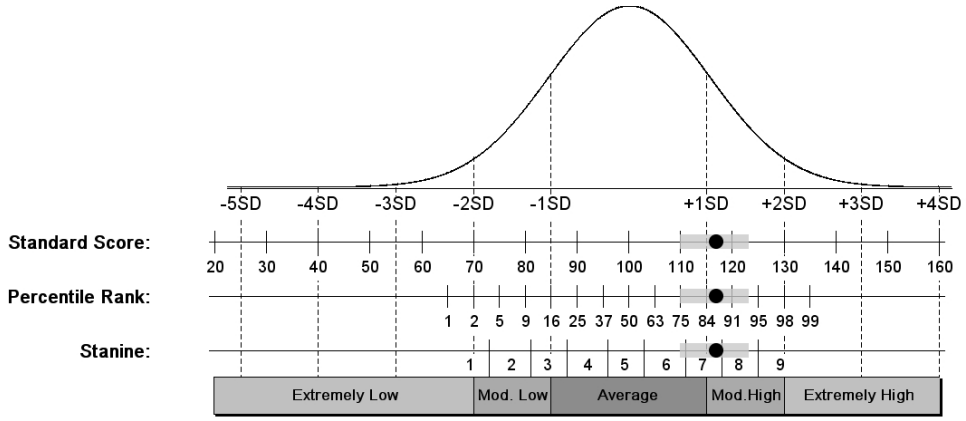

Figure 6-31 EVT-2 Gretel Baseline 1

Gretel's Baseline 1 comprehension level of 37 as measured by the TORCH: 3 was well above the mean average of 34 for a Year 3 level, even though she was only in Year 2. She scored 8 out of 24 on the Baseline 1 App comprehension test and subsequent tests remain consistent on and around this score. These data are similar to those measured by the TORCH: 3 with a small gain in results when she was using the App intervention between Baseline 2 and Post-test 1.

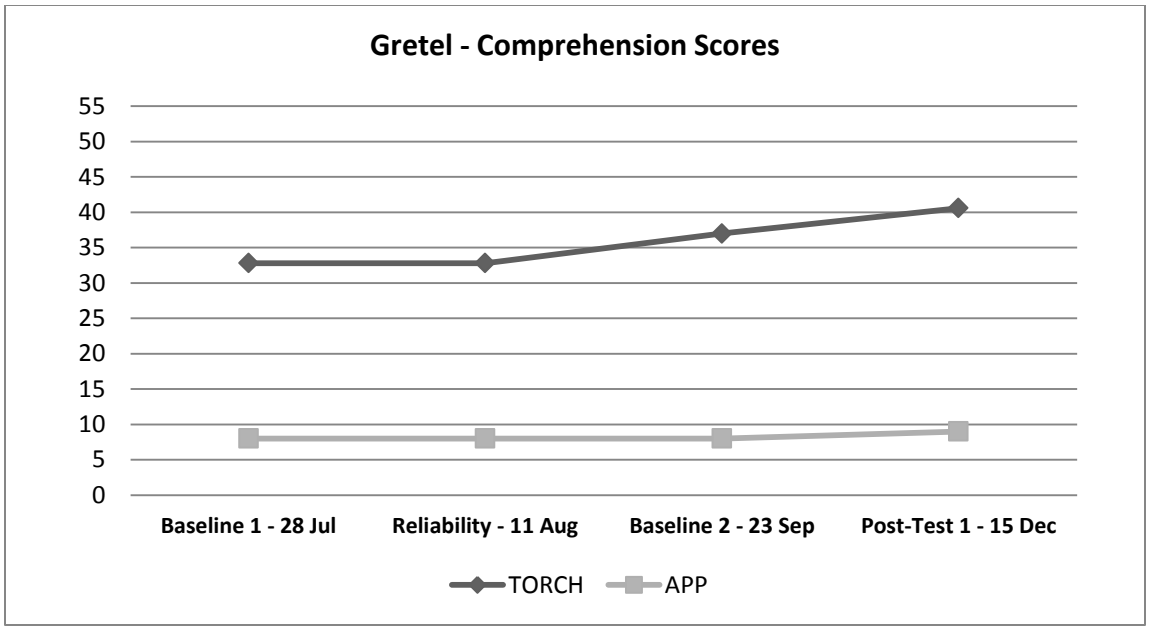

Figure 6-32 Comprehension Tests TORCH: 3 and App Comprehension Test

Notes recorded by the researcher at Baseline 1 report that Gretel read very fluently and with accuracy. Gretel's post-intervention notes taken by the researcher report that she enjoyed using the App and in particular, the 'picture builder' function. She mentioned that she did not mind answering the questions as they, "helped me remember what was going on." It was noted in Baseline 1 data collection and in Post-test 1 that when answering comprehension questions, Gretel did not go back into the text to actively look for the answer to a question, nor did she ask for assistance. Gretel's results from the App show no errors in inferences or with anaphors and some sequencing errors were recorded.

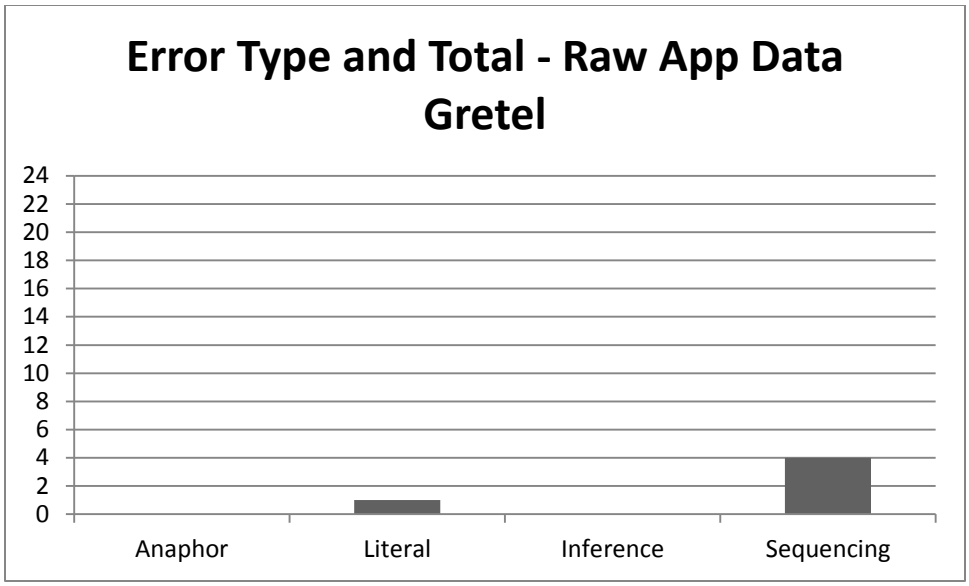

Figure 6-33 Downloaded data retrieved from App Intervention – Gretel

Participant Mack

Mack was aged 11 years and 10 months at the time he commenced the study and was the eldest of all nine participants. Mack had received a preliminary diagnosis of HFASD from a registered Child Psychologist from the Department of Education Tasmania, and was waiting for a formal assessment through the Tasmanian Autism Diagnostic Assessment Service (TASDAS). He attended a mainstream primary school and was enrolled in Year 6. Mack was a talkative student although he appeared to lack confidence in his school work. His teacher reported that Mack had a number of difficulties over the course of the school year and was working hard to focus more on his school work (in particular mathematics and literacy), and working with other students. Mack's teacher explained that he showed many deficits in his literacy. Mack reported that he did not enjoy reading a lot at home or in class, did not like taking reading tests in school, and preferred to watch television rather than read. On the reading attitude survey Mack indicated

that his favourite texts were information books concerning different countries, comics, and sports magazines. His results from the Phonological Awareness Test showed no indication of any phonological deficits as these were at ceiling level on all of the sub-tests.

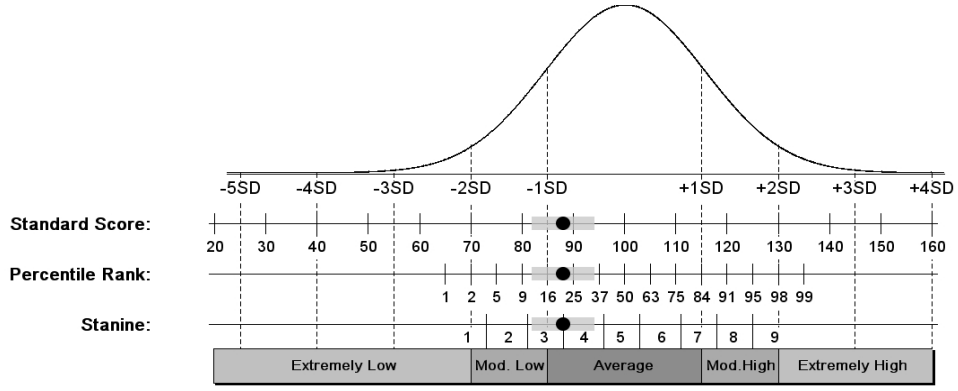

Figure 6-34 PPVT-4 Mack Baseline 1

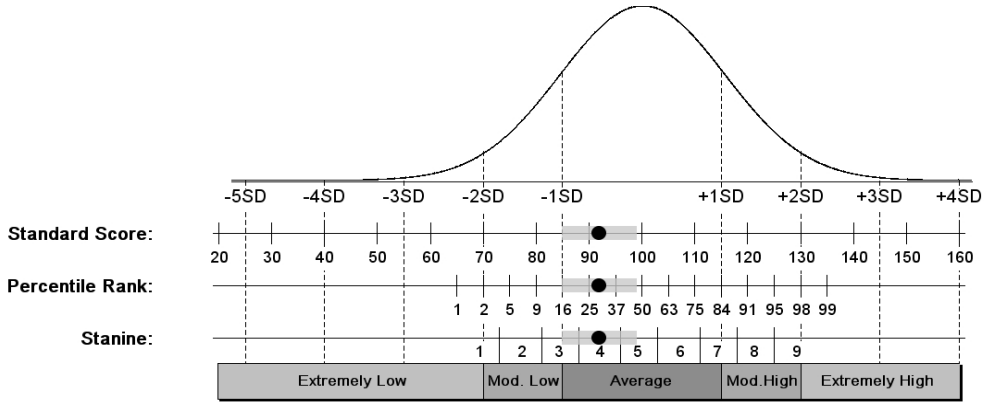

Figure 6-35 EVT-2 Mack Baseline 1

Mack's receptive and expressive vocabulary levels were in the low range of average for his chronological age. These data were collected at Baseline 1 on commencement of the study and remained consistent through Baseline 2 and Post-test 1 whilst he was using the App

intervention. Mack used the App intervention for three of the six weeks allocated for the intervention due to school administrative difficulties.

Mack's comprehension levels as measured by the TORCH: 3 at Baseline 1 were well below his Year 6 level at 17.2, where the year mean is 47.5. He scored 5 out of 24 on the initial App Comprehension Test. Mack's profile shows a gain in the TORCH: 3 between Baseline 1 and Baseline 2 from 17.2 to remaining stable around 28 at Post-test 1. Over this period Mack was not involved in the intervention. Mack began the intervention well after Baseline 2 and his results show little change in the TORCH: 3 and the App comprehension test at Post-test 1.

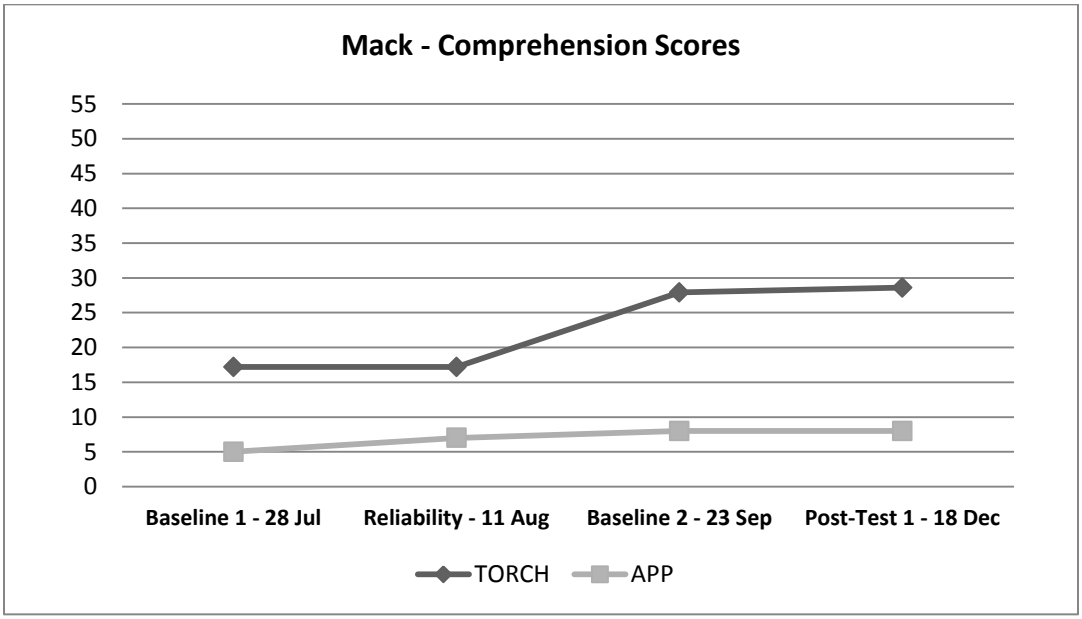

Figure 6-36 Comprehension Tests TORCH: 3 and App Comprehension Test

Researcher notes report that Mack 'shut down' at times when completing his reading assessments for the intervention. He wanted to read the first sentence and then answer the first

question. When he couldn't find the answer he would repeatedly say, "I don't get it." He was provided with encouragement from the researcher, and repeated instructions on completing the tests such as leaving the questions he could not answer. He would still remark, "it's too hard and there are too many questions," and appeared to become anxious. When answering the comprehension questions, he did not go back and read the texts again after the initial readings. It is not clear whether he had read the whole text for testing even as he remarked at the time that he had, and needed a lot of encouragement to complete the assessment tasks.

After using the App, remarks recorded in notes by the researcher describe that Mack found the App very easy, a 'fun' way to read, and "better than a normal book." He explained that he read the App story without the audio function, and seemed pleased that he did not need to use many hints. His App data corresponds with these remarks, however, show in the same way as other participants, that he did have some difficulties in sequencing events.

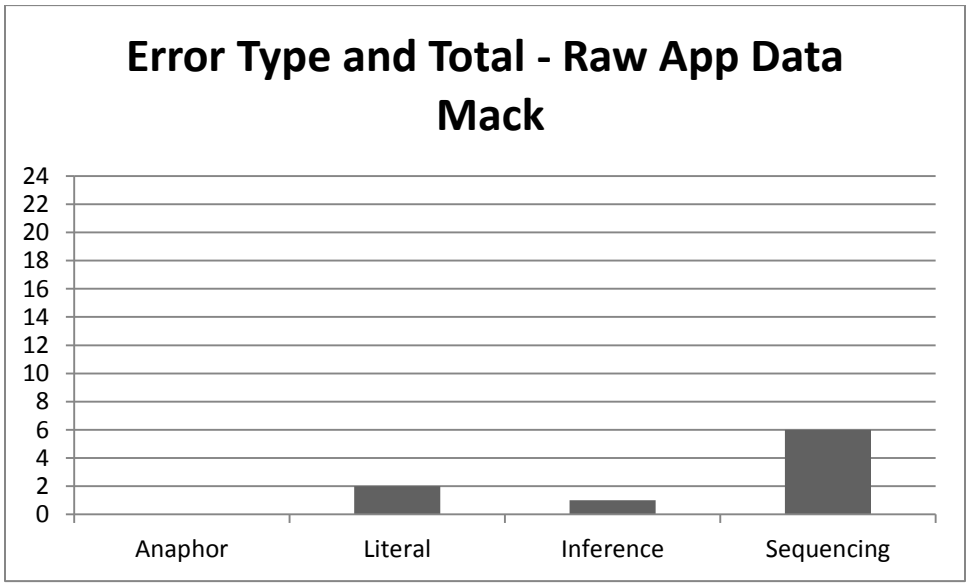

Figure 6-37 Downloaded data retrieved from App Intervention – Mack

Chapter 7 – Discussion and Conclusions

7.1 Introduction

This chapter provides an overview of the study, a review of the questions and aims, and a discussion the findings and possible implications, in relation to current literature and theoretical frameworks relevant to reading comprehension, students with HFASD, and educational software design. The discussion highlights the emerging issues and themes that resulted from the data analysis. These have been aligned with the literature within their respective fields and discussed in reference to their context. The study's limitations are addressed, and recommendations for future research are offered before concluding.

7.2 Overview

The present study measured gains in reading comprehension after the administration of a research designed App created for iPad technology. The study was undertaken in response to the need for effective interventions in the field of special education, specifically HFASD, and the limited availability of empirical evidence concerning effectiveness of new educational technologies (Kagohara et al., 2013; Knight et al., 2013; Stephenson & Limbrick, 2013; van der Meer et al., 2015). The instruments chosen to determine the effectiveness of the intervention on students with differing HFASD profiles focused on the students' oral language ability and their reading comprehension levels. This approach was selected due to the relationship between reading comprehension and oral language in students with HFASD (Nation et al., (2006) and the need to research within and across the ASD phenotype (Ricketts et al., 2013).

The aims of the present study were to:

1. Synthesise research findings on reading comprehension difficulties for students with HFASD and identify the evidence-based strategies that can support improvements;
2. Determine the main issues and features associated with the design of quality educational software;
3. Embed evidence-based reading comprehension strategies and key features of quality
4. educational software into an interactive 'App' format;
5. Apply the App as an intervention.
6. Evaluate the effectiveness of the approach in applied settings by measuring the key factors that underpin the development of effective reading comprehension skills in students with HFASD;
7. Analyse the results and report the findings.

These aims allowed the study to provide answers to the following questions:

"Can App software be designed to support measurable gains in reading comprehension for students with HFASD?"

Under the primary research question sits these sub-questions:

a. "What are the key criteria and design features to consider when creating educational software for mobile technologies?"

b."Considering the heterogeneous nature of individuals with HFASD, what attributes or characteristics influence students' results after using the software?"

7.3 Discussion

7.3.1 Reading Comprehension, students with HFASD, and Theoretical Considerations

The study was undertaken in response to research that has shown that students with HFASD demonstrate more difficulty with reading comprehension than their typically developing classroom peers without HFASD (Jones et al., 2009; Nation et al., 2006; Nation & Hulme, 2011; Norbury & Nation, 2011). This difficulty was also identified in the cohort of students with HFASD who participated in the present study. These difficulties suggest there may be an interaction effect between how comprehension is typically taught in schools (face-to-face interactions) and the characteristics of students with HFASD (Ricketts et al., 2013; Saalasti et al., 2008). Some of these interaction effects could relate to this cohort in respect to difficulties with executive functioning (Joseph et al., 2005; Saalasti et al., 2008), problems with social competency, and an ability to comprehend emotions (Jones et al., 2009; Ricketts et al., 2013). Typically, in students with HFASD the reported core social and language deficits and a reduced capacity to acquire Theory of Mind (ToM; Frith, 1989; Meltzoff, 1999), can manifest in a reduced ability to interpret information in a face-to-face environment.

One of the main theories to explain why students with HFASD have more difficulty with reading comprehension relates to their often reduced verbal ability (Nation et al., 2006). Reading comprehension is underpinned by a student's ability to fluently decode and understand words, and these words create a schema of the text that is necessary for comprehension to occur (Gough & Tunmer, 1986). This ability to rapidly comprehend at the word level is important in forming a schema (understanding) of the text (Bishop & Snowling, 2004). If the reader is too slow, the information is not effectively transferred from the short term memory into long term

memory (Baddeley, 2000) where comprehension at the sentence and passage level is achieved (Bishop & Snowling, 2004; Therrien, 2004). As such, reading comprehension is linked to the student's ability to effectively and quickly decode and recognise words, and to understand the meaning of those words within the text (Gough & Tunmer, 1986). Students with HFASD often have difficulty with receptive and expressive vocabulary (Saalasti et al., 2008), therefore their ability to understand words can be impaired (Nation et al., 2006). This factor can also mean that students with HFASD are less effective in forming a schema of the text, thus impairing comprehension. The findings from this study align with and lend support to previous research which proposed that the underpinning vocabulary skills of a student have an impact on their comprehension (Muter & Diethelm, 2001; Nation et al., 2010; Nation & Norbury, 2005). The present study identified that there was a positive correlation between the students with HFASD and: their receptive language ability as measured by the PPVT-4; their expressive language ability as measured by the EVT-2; and their scores on the TORCH: 3 reading comprehension test. These measures reveal that post-intervention, the largest gains in reading comprehension were from those students who had demonstrated greater deficits across the domains of expressive and receptive language and comprehension. This emphasises the importance of targeting oral language development in the context of developing effective learning programs to support reading comprehension for students with HFASD.

Another implication for educational theory that can be drawn from this research supports the use of explicit teaching and the practice of evidence-based strategies as an effective method in ameliorating the problems exhibited by students with some level of learning difficulty (Lang et al., 2010; Therrien, 2004). Previous research (Carberry, 2014; Therrien, 2004; Woolley, 2011)

has noted that for students with reading comprehension difficulties, the explicit practicing of strategies allows students to develop their: (1) vocabulary; (2) fluency; (3) ability to link text together; and (4) to reflect on and revisit the text. These four strategies were embedded into the App intervention and were explicitly practiced as the students completed the intervention. In the App, these four strategies were related to the students' anaphoric comprehension, literal comprehension, inferential comprehension, and sequential comprehension. The majority of the students in the present study enhanced their reading comprehension as shown by their TORCH: 3 or App comprehension test scores. This reinforces the need to provide students with HFASD explicit and systematic practice of relevant reading comprehension strategies as an effective method for improving their comprehension. As a result, a much greater range of academic skills can be supported.

7.3.2 Technology and Students with HFASD

For students with a history of reading or comprehension failure, their reading problems need to be addressed within a supportive context (Woolley, 2011). It is important to recognise that students with a history of reading failure do not feel stigmatised or are treated in a way that is not age appropriate or respectful (Woolley, 2011). Therefore, removing the negative experiences of many students with reading failure is an important outcome of an intervention. The comments from the participants in this study indicated that the iPad App provided a positive learning platform for supporting reading comprehension difficulties for students with HFASD. The decision to use iPad technology to embed the intervention is supported by research indicating that students with HFASD respond positively to learning activities associated with

technology (Kagohara et al., 2013; Knight et al., 2013; Stephenson & Limbrick, 2013; van der Meer et al., 2015). These results emphasise the need for specifically designed curriculum resources for students with HFASD so that the learning needs of this cohort of students can, in part, be accommodated through adaptive technology and adaptive e-learning activities (Armstrong & Hughes, 2012; Kagohara et al., 2013; King et al., 2014). As new mobile technologies are now well integrated into mainstream and special educational classrooms, emphasis is needed not only in the learning content of the software, but in the way the educational App will support and scaffold the learner.

The findings support the suggestion that technology-based interventions for students with ASD and other developmental disorders should use well-established instructional strategies, such as graduated guidance and differential reinforcement (Duker et al., 2004). The App software employed as the intervention for this study provided instruction that was systematically presented and provided opportunities for the students to revise or re-read. Lang et al., (2010) explained these features are required in order to support the development of academic, social and communication skills for students with HFASD. The findings of the present study demonstrate that prior to commencing the intervention, more than half of the participants' comprehension strategies were not well established and so the students' reading comprehension was below grade expectations. Through the systematic presentation and revision of the embedded comprehension strategies within the App, these strategies were consolidated for those students exhibiting the greatest deficits in language and comprehension. Therefore, the App intervention explicitly supported the development of the strategies that increased these students' ability to comprehend

information in a regularly presented format, shown in their improved results on the TORCH: 3 and App comprehension tests.

7.3.3 App Data

Another way to interpret the students' results is to examine the data on error rates drawn from the App intervention. Across all of the embedded tasks incorporating anaphoric comprehension, literacy comprehension, inferential comprehension, and sequential comprehension, there were fewer errors associated with anaphor comprehension, (the ability to understand pronouns). These results are in contrast to the thesis of O'Conner and Klein (2004) who identified the resolution of anaphors (pronouns) in text as a possible weakness in students with HFASD. The results of participants' error rates in the App data show that sequential comprehension was typically the weakest dimension of the four across this cohort of participants. This weakness in sequential comprehension, as proposed by Ozonoff et al. (1991), can be related back to students with HFASD having more difficulties with their executive function. Ozonoff et al. also maintained that individuals with ASD demonstrated more cognitive difficulties with flexibility, planning, organization, and self-monitoring and these difficulties were assumed to be within the Executive Function (EF) of individuals with ASD. The students' weaknesses with sequential comprehension, and their associated difficulties in organising information from text, can also be interpreted from the perspective of Weak Central Coherence Theory (WCCT; Happe & Frith, 2006; Williamson et al., 2009; 2012). This theory maintains that students with HFASD display more difficulties in forming a coherent schema of the presented information and are more distracted by less relevant aspects of text or oral information. In terms of reading comprehension

and students with HFASD, Williamson et al. (2012) proposed that one of the possible causes of these students with HFASD having a reduced ability to organise, sequence, and summarise information was related to their difficulties in accessing relevant background knowledge and identifying the main idea of the text from the distracting information within the text. Williamson et al., identified these readers as 'text bound comprehenders.' They argued that interventions to address this weakness needed to be explicitly taught. They explained that these interventions should introduce the students with HFASD to structured activities around accessing prior knowledge (schema) of a topic, and activities that practice the organisation of information. These sequencing activities will support students with HFASD in identifying the main idea in a story, and linking this information back to the wider topic under investigation in the text.

The data downloaded from the App revealed that the participants with higher error rates had also demonstrated more impaired comprehension on the TORCH: 3 and App comprehension test in Baseline 1 testing. These participants made the greatest gains on both the TORCH: 3 and the App comprehension tests post-intervention. The errors appeared across the four domains of anaphoric comprehension, literacy comprehension, inferential comprehension, and sequential comprehension (see Table 6.4). As these data were summative, it was not possible to track improvements throughout their use of the App. Three of the four students who demonstrated fewer errors on the App data only showed small gains on the TORCH: 3 (see Table 6.3). These results can be examined with research on students' reading levels (Duke & Pearson, 2002) as articulated by Holdaway (1972) and McNaughton, Glynn, and Robinson (1981). The suitability of a text for a reader can be rated at either independent level, instructional level, or frustration level (Holdaway, 1972; McNaughton et al., 1981). It could be proposed that those participants

with fewer errors in the App data, and average to better results on the TORCH: 3 and App comprehension tests could be considered to be reading the App intervention text at an 'independent' level. This is where a child can read alone, with ease, with few errors, and with 80 to 100 % comprehension. Therefore, for these participants with higher Baseline 1 comprehension levels, there were fewer gains to be made post intervention. The participants who evidenced higher error rates in the App data and who had demonstrated weaknesses in their comprehension shown by Baseline 1 measures on the TORCH: 3 and App comprehension test could be described as operating more to an 'instructional' level. This is where reading comprehension is around 80%. The participants who demonstrated higher gains post-intervention had also recorded low vocabulary levels on the PPVT-4 and EVT-2. Therefore, the sustained practice of the comprehension strategies and scaffolded support embedded within the App intervention had a positive impact on the students' reading comprehension resulting in higher gains across post-intervention tests. These findings reinforce the need for educational software supporting reading comprehension to consider how to provide opportunities for the reader to be challenged at the appropriate level.

7.3.4 Examination of Specific Profiles

The interviews conducted with each of the participants over the course of the study were designed to contribute valuable qualitative information to the research. These interviews also provided an insight into the personal attributes or 'qualitative' characteristics of each participant, and were incorporated so they could be examined alongside the quantitative data. Closer inspection of the qualitative data sourced from teaching notes, researcher questions, and

observations of four of the participants, Hanna, Larry, and Mark, described their personalities as either socially shy or withdrawn. Analysis of the quantitative data recorded by these three participants showed impairments in reading comprehension and vocabulary. This was in contrast to participants Abby, Ken, and Gretel. The qualitative data described these students as confident or social, and their quantitative data recorded levels that were above average, with predominantly average reading comprehension levels. Given the close relationship between students' level of oral language, social communication, and reading comprehension, Ricketts et al. (2013) raised the possibility that students' deficits in their reading comprehension *and* their social communication may be underpinned by their oral language comprehension impairments. Contrasting the profiles from the present study in this manner supports this theory, particularly when taking into consideration the core social and language deficits associated with children with ASD (Frith, 1989; Meltzoff, 1999).

The variability of students with HFASD in relation to their level of social competence, oral vocabulary, and comprehension were exemplified in comparative data between the two brothers, Larry and Ken and how they responded to the App intervention. Even though they were parented within the same household, their HFASD profiles are markedly different. This again underscores the heterogeneity of the spectrum (Nation et al., 2006). Larry's data showed his expressive and receptive vocabulary at almost two standard deviations (-2SD) below his chronological age of nine years, and he had highly impaired comprehension. Larry's teacher identified him as shy and withdrawn. His brother Ken revealed a profile with above average receptive vocabulary, expressive vocabulary at one and a half standard deviation above average (+1.5SD). Ken was described by his teacher as having excellent comprehension. An

improvement in reading comprehension post-intervention was established in Larry's results but not Ken's, as Ken consistently maintained higher than average comprehension across both the App comprehension and the TORCH: 3 tests. These results can again be interpreted from the theoretical perspective of ToM (Frith, 1989) and how social deficits impact upon face-to-face interactions. Larry's results indicated that supplementing traditional teaching and learning strategies with mobile technology which retained the authenticity of the learning task (Walker, 2014) can assist individuals with HFASD. Larry's results, in part, support the claim that those individuals with low social competency, comprehension, and oral vocabulary can benefit from the opportunity to be more self-directed in their learning through the use of technology (Kagohara et al., 2012; Knight et al., 2013; van der Meer et al., 2015). This means that students can benefit from practising strategies at their own pace, and revisit those activities in a supportive and scaffolded learning context (Duker et al., 2004; Nikolopoulou, 2007). As mobile technologies are designed to be easily portable, educational Apps can maximise the benefits of self-paced learning inside and outside the classroom context.

An unexpected finding that arose from the intervention was recorded in Larry's qualitative data. Prosodic speech abnormalities, or speech which is parroted, over-exaggerated, monotonic, and at an atypical pitch, rhythm or intonation, are often observed across students with ASD (Järvinen-Pasley et al., 2008). These are commonly at the phrasal (sentence) rather than the individual word level (Peppé et al., 2007). Larry's profile consisted of very low expressive and receptive vocabulary, which indicated a verbal age of around five years despite his age of nine years. After completing the intervention, the researcher recorded that he read with prosody (expression) when reading aloud the App comprehension test. It was confirmed by

Larry's classroom teacher, that he had not read with prosody prior to the intervention. Larry was one of three participants who described listening to the App as he was reading the text. Nikolopoulou (2007) explained the need for the adaptation of software content so that it meets the technical requirements of users and is relevant within cultural contexts. This is even more pertinent considering the nature of the present study with a focus on language, vocabulary, and comprehension. The indications are that the audio feature within the App which narrated the text in a culturally appropriate and standard accented-human voice (Churchill, 2011; Falloon, 2013) may have contributed to these prosodic speech improvements. It is not known though, if these prosodic improvements were able to be generalised as this was not anticipated prior to commencing this study.

7.3.5 Selecting e-Resources

The findings of this research demonstrate that Apps can be designed to support and develop critical academic skills such as reading comprehension for some individuals with HFASD. Although the overall finding is positive, there were variable outcome for the participants. Measured improvements have been demonstrated in the results of the intervention from those students with determined deficits in oral vocabulary, and specific integrative skills such as sequencing and sourcing literal and inferential information from text. Holdaway (1972) made the point that improvements in reading and reading comprehension occur within a learning environment where the reader's personal reading performance is enhanced. As discussed previously, classroom reading environments that are competitive and not supportive or engaging for students, will reduce students' interest in reading; their enjoyment of reading; their

development of reading as an independent activity; and their reading comprehension (Woolley, 2011). In particular, the reading material needs to be at the student's 'appropriate level of instruction' (McNaughton et al., 1981). Finding the 'right' reading book for students with reading problems is a complex issue. There are books available that have been designed so that they are age appropriate for readers in terms of content and subject, but may have more of a controlled vocabulary and reduced complexity of structure (Knowles & Smith, 2005). The App, 'The Adventures of Billy Possum', may hold more interest to students in the lower and middle primary grades because of its greater focus on animals, family, and adventure. Certainly, qualitative data recorded from participants at post-intervention, in the form of comments and remarks support this claim (see individual profiles chapter 6.4 for individual examples). Exceptions to the many positive remarks made by participants were comments recorded in the pilot study from Sam. He stated that he would rather read his own book and remarked, "I don't want to be rude or offend, but I find the App a bit childish." Sam recorded a small gain on the App comprehension test in comparison to Tim who asked the researcher where he could get the next story to follow on from the intervention text. These results underscore the importance of creating educational software that is motivating and engaging whilst at the same time pedagogically appropriate to support the development of targeted skills (Hedman & Gimpel, 2010). The results from participants in the present study reinforce this.

7.3.6 Addressing the Research Questions

More broadly, the research conducted in this study has highlighted the importance of understanding the efficacy of specific software classified as 'educational.' Importantly, the

findings have established the necessity of understanding what works and for whom it works best (Li et al., 2000). The results of the present study have shown the impact of purposefully designed App software upon the reading comprehension of students with HFASD. These results have also reiterated the heterogeneous nature of students with HFASD (Nation et al., 2006) by determining many strengths and weaknesses of these students in vocabulary, comprehension, phonological, social, and behavioural attributes. The key findings from the present study established that the more sizable gains in reading comprehension were demonstrated by those students who had the greatest deficits across the domains of expressive and receptive language and comprehension. This finding contributes to the research literature by confirming that software for mobile technologies can be designed to support critical literacy skills for students with HFASD. Furthermore, the impact of the App intervention upon the various profiles of participants with HFASD in this study indicated specific attributes and characteristics of those students that have influence on improvements in reading comprehension. These factors are represented quantitatively: by recorded deficits in vocabulary and comprehension; and qualitatively in teachers, participants, and the researcher's questions, observations, and comments. Overall, these results underscore the importance of understanding the discrete nature of the particular strengths and weaknesses of students with HFASD when targeting learning, as a 'one size fits all' approach will not be effective for every student.

The results and findings of the present study have also validated the importance of incorporating specific elements in the design and creation of educational software. To design and create the App software that was implemented to improve reading comprehension for students with HFASD, this study was required to consider and justify: (1) the necessary

evidence-based strategies to embed for students with HFASD; (2) the way in which the software would support the students' learning in presentation, scaffolding, and support; (3) the appropriateness of the content for the age and context of participants to maximise engagement and motivation; and (4) the exclusion of elements that may distract or inhibit a student's learning processes.

7.4 Limitations

Although the present study is underpinned by sound research design, it does have its limitations. This study has focused on the development of one App and embedded what was identified as the relevant strategies to improve the participants' reading comprehension. Ideally, more than one App should be available to meet the range of topics and genre that interest students with reading and comprehension difficulties.

The use of the single subject quasi-experimental case design indicated that the students with HFASD were making limited progress in terms of their reading comprehension as measured by the TORCH: 3 prior to the intervention. The findings of this study suggest students' development of their reading comprehension was 'improved' by the intervention. Given the sample size and design of the study, confirmation of whether the App is as effective as the findings in this study suggest, requires other researchers to replicate the findings. Similarly, while every effort was made to identify students with HFASD using external validation of this diagnosis by qualified professionals, how typical this cohort of students is, in respect of the total population of HFASD students is undetermined. Again, the study needs replication with other cohorts of students with HFASD in other settings and other countries.

It also needs to be recognised that for students with reading comprehension deficits, it can take longer than a short-term intervention to remediate their individual difficulties. Ideally, the students should have additional resources and support over a longer period of time. The findings from the present study need to be interpreted from the perspective that the App has improved comprehension for some participants, but it has not 'repaired' the students' reading comprehension difficulties.

Closely following the quality indicators for treatment fidelity set out by Gersten et al. (2005) for Special Education Research, the present study had strengths particularly due to the consistent nature of the delivery of the independent variable (the App). Each participant received the identical intervention from using the App software, meaning the learning content was received in exact replication. There remains some limitation concerning the 'consistency' of treatment fidelity. By nature, participation in an intervention where individuals are located in various school settings is problematic and affects surface fidelity. In this instance, these various school settings resulted in some inconsistencies concerning the number of sessions made available to participants, the length of time for each session, and how regularly these were provided due to differing classroom demands. Instances such as a participant's illness or a change from mainstream schooling to home schooling could possibly create some inconsistencies in the frequency of interaction with the intervention. These have been described when necessary in *Chapter 6* as part of the participants' results. These circumstances were considered to have little to negative impact on treatment fidelity.

7.5 Directions for Future Research

The present study is one of the first to consider the acquisition of critical literacy skills for students with HFASD. It was specifically designed to target the learning needs of this cohort of students. How e-learning can be adapted for individuals with ASD is a developing field of research within the domain of developmental disabilities. Adaptive technology and specific programs require further research and development in order to better understand and assist those students with ASD and some of the learning difficulties associated with the ASD diagnosis.

In regards to critical academic skills such as reading comprehension, the exploration of various vocabulary profiles has clearly shown that this mode of delivery can work for those with specific deficits. Close examination of these deficits and their variability in those students with HFASD, including additional elements such as social competency, should remain a key consideration when researching in this field. Exploring the idea that face-to face teaching methods can create a barrier to learning for some students with HFASD opens up new research opportunities to further examine how appropriately designed software that closely replicates a pedagogic teaching process, can support the acquisition of critical skills in different academic domains. As such, it would be useful for future studies investigating the use of mobile technologies and ASD to incorporate quantitative measures of social competence. This would enable researchers to more closely examine and understand the teaching/learning relationship and the factors which contribute to academic gains. More specifically, this may be understanding how technology mediates the difficulties associated with the acquisition of complex academic skills in those individuals who may demonstrate greater impairments in social competency related to ToM (Baron-Cohen et al., 1985; Frith, 1989).

Future research in this field could more closely examine prosodic (language expression) improvements (such as those shown by Larry), and undertake a broader investigation into how mobile technologies can support the development of vocabulary and pragmatic communication. Undertaking this research can provide a clearer understanding of how specific software features within mobile technologies such as audio and text, can address prosodic impairments to support the development of language and expression for students with ASD.

More broadly though, the present findings have emphasised the importance of the role of vocabulary in reading comprehension and students with ASD (Nation et al., 2006). Findings from the present study that underscored the relationship between social competency and vocabulary (Ricketts et al., 2013) are another way of extending work in this field. For example, future studies may examine more closely expressive rather than receptive levels of vocabulary and their relationship to comprehension and social competency. By understanding how these three factors impact and interact with each other across various profiles of students with ASD, educators and developers will be better equipped to design and improve software products for targeted and evidence-based educational supports.

7.6 Conclusion

This study was motivated by the importance of supporting students with HFASD with deficits in reading comprehension. The benefits of developing effective reading skills for any student cannot be overstated, as they have lifelong impacts that influence an individual's level of personal and professional attainment. With the widespread adoption of new mobile technologies into mainstream and special education contexts, it is important to understand what software

works and for whom it works best. To achieve this, the present study posed questions and developed aims to ascertain if purposefully designed App software for mobile technologies could provide measureable gains in reading comprehension for individuals with HFASD. This study has drawn together several key theories that underpin possible explanations for reading comprehension deficits in students diagnosed with HFASD. Theories such as Theory of Mind (ToM; Baron-Cohen et al., 1985; Frith, 1989), Weak Central Coherence Theory (WCCT; Happe & Frith, 2006), and Executive Dysfunction Theory (EDT; Pennington et al., 1997), have been brought together with research concerning reading comprehension and evidence-based practice. These theories were used to frame the features and function of the App software developed as the intervention for this study. As a result, the findings of this study address a gap in the literature concerning the effectiveness of new mobile technologies and their ability to develop critical literacy skills for students with HFASD.

This original research has answered the research questions and determined that App software can be designed to support measurable gains in reading comprehension for students with HFASD. Furthermore, the results have revealed the attributes and characteristics of students with HFASD that influenced their results. These results are important when developing an understanding of the key criteria and design features of educational software and technology based education tools. The present study has also achieved its aims which were to synthesise previous findings on reading comprehension difficulties in students with HFASD and embed these remedial strategies identified by research into an interactive App format. The App, 'Billy Possum's Interactive Comprehension' was employed as the intervention in a single-case quasi-experimental design study. The impact of the intervention was evaluated through the

implementation of a pilot and main study, to determine its effectiveness and report the findings. From addressing the aims and answering the research questions central to this thesis, the findings contribute deeper understandings in the way App software for mobile technologies can support students with HFASD, and how they can be designed to deliver educational content, necessary for the development of critical academic skills.

"The more that you read, the more things you will know.
The more that you learn, the more places you'll go." (Seuss, 1978)

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Appendix A:

Human Research Ethics Committee (Tasmania) Approval

Social Science Ethics Officer
Private Bag 01 Hobart
Tasmania 7001 Australia
Tel: (03) 6226 2763
Fax: (03) 6226 7148
Katherine.Shaw@utas.edu.au

HUMAN RESEARCH ETHICS COMMITTEE (TASMANIA) NETWORK

UTAS

7 February 2013

Assoc Prof Ruth Fielding-Barnsley
Faculty of Education
Locked Bag 1308

Student Researcher: Michelle Somerton

Sent via email

Dear Assoc Prof Fielding-Barnsley

Re: FULL ETHICS APPLICATION APPROVAL
Ethics Ref: **H0012932 - Reading Between the Lines: Embedding research-based teaching strategies into iPad technology for students with Autism**

We are pleased to advise that the Tasmania Social Sciences Human Research Ethics Committee approved the above project on 5 February 2013.

This approval constitutes ethical clearance by the Tasmania Social Sciences Human Research Ethics Committee. The decision and authority to commence the associated research may be dependent on factors beyond the remit of the ethics review process. For example, your research may need ethics clearance from other organisations or review by your research governance coordinator or Head of Department. It is your responsibility to find out if the approval of other bodies or authorities is required. It is recommended that the proposed research should not commence until you have satisfied these requirements.

Please note that this approval is for four years and is conditional upon receipt of an annual Progress Report. Ethics approval for this project will lapse if a Progress Report is not submitted.

The following conditions apply to this approval. Failure to abide by these conditions may result in suspension or discontinuation of approval.

1. It is the responsibility of the Chief Investigator to ensure that all investigators are aware of the terms of approval, to ensure the project is conducted as approved by the Ethics Committee, and to notify the Committee if any investigators are added to, or cease involvement with, the project.

2. Complaints: If any complaints are received or ethical issues arise during the course of the project, investigators should advise the Executive Officer of the Ethics Committee on 03 6226 7479 or human.ethics@utas.edu.au.

3. Incidents or adverse effects: Investigators should notify the Ethics Committee immediately of any serious or unexpected adverse effects on participants or unforeseen events affecting the ethical acceptability of the project.

4. Amendments to Project: Modifications to the project must not proceed until approval is obtained from the Ethics Committee. Please submit an Amendment Form (available on our website) to notify the Ethics Committee of the proposed modifications.

5. Annual Report: Continued approval for this project is dependent on the submission of a Progress Report by the anniversary date of your approval. You will be sent a courtesy reminder closer to this date. **Failure to submit a Progress Report will mean that ethics approval for this project will lapse.**

6. Final Report: A Final Report and a copy of any published material arising from the project, either in full or abstract, must be provided at the end of the project.

Yours sincerely

Katherine Shaw
Ethics Officer
Tasmania Social Sciences HREC

Appendix B:

Approval for amendment to current research project

Social Science Ethics Officer
Private Bag 01 Hobart
Tasmania 7001 Australia
Tel: (03) 6226 2763
Fax: (03) 6226 7148
Human.ethics@utas.edu.au

HUMAN RESEARCH ETHICS COMMITTEE (TASMANIA) NETWORK

UTAS

24 March 2014

Assoc Prof Ruth Fielding-Barnsley
Faculty of Education
Private Bag 66

Sent via email

Dear Assoc Prof Fielding-Barnsley

Re: APPROVAL FOR AMENDMENT TO CURRENT PROJECT
Ethics Ref: **H0012932 - Reading Between the Lines: Embedding research-based teaching strategies into iPad technology for students with Autism**

- Amendment to recruit participants through Catholic Education Tasmania (CET) via Principals of Catholic Education Schools.
- Information Flyer for Catholic Education.

We are pleased to advise that the Chair of the Tasmania Social Sciences Human Research Ethics Committee approved the Amendment to the above project on 20 March 2014.

Yours sincerely

Katherine Shaw
Executive Officer
Tasmania Social Sciences HREC

Appendix C:

Evaluation Rubric for Mobile Apps – Walker (2014)

Evaluation Rubric for Mobile Applications (APPS)

Domain	4	3	2	1
Curriculum Connection	Targeted skill or concept is directly taught through the app	Skill(s) reinforced are related to the targeted skill or concept	Skill(s) reinforced are prerequisite or foundation skills for the targeted skill or concept	Skill(s) are not connected to the targeted skill or concept
Authenticity	Targeted skills are practiced in an authentic format/problem-based learning environment	Some aspects of the app are presented an authentic learning environment	Skills are practiced in a contrived game/simulation format	Skills are practiced in a rote or isolated fashion (e.g., flashcards)
Feedback	Feedback is specific resulting in improved performance; Data is available electronically to student and/or teacher	Feedback is specific and results in improved student performance (may include tutorial aids)	Feedback is limited to correctness of student responses & may allow for student to try again	No feedback is provided to the student
Differentiation	App offers complete flexibility to alter settings to meet student needs	App offers more than one degree of flexibility to adjust settings to meet student needs	App offers limited flexibility (e.g., few levels such as easy, medium, hard)	App offers no flexibility (settings cannot be altered)
User Friendliness	Students can launch and navigate within the app independently	Students need to have the teacher review how to the use the app	Students need to have the teacher review how to the use the app on more than one occasion	Students need constant teacher supervision in order to use the app
Motivation	Students are highly motivated to use the app and select it as their first choice from a selection of related apps	Students will use the app as directed by the teacher	Students view the app as "more schoolwork" and may be off-task when directed by the teacher to use the app	Students avoid the use of the app or complain when the app is assigned by the teacher
Student Performance	Students show outstanding improvements in performance as a result of using the app	Students show satisfactory improvements in performance as a result of using the app	Students show minimal improvements in performance as a result of using the app	Students show no evidence of improved performance as a result of using the app

Created by Harry Walker – Johns Hopkins University -10/18/2010; Revised & empirically validated 10/14/2012
Please contact for permission to use harry.walker@comcast.net

Appendix D:

Adapted Text with embedded learning content for App conversion

THE ADVENTURES OF UNC' BILLY POSSUM

ADAPTATION FOR APP BUILD

CHARACTERS

BILLY POSSUM
REDDY FOX
PETER RABBIT
MR. TOAD
BOBBY COON (Koala)
JUMPER THE HARE
SHADOW THE WEASEL (Snake)
JIMMY SKUNK (goanna)
FARMER BROWN
MR SKIMMER THE SWALLOW
SAMMY JAY (Galah)
BLACKY THE CROW
JOHNNY CHUCK (Emu)
(Paula Pygmy Possum)
DRUMMER THE WOODPECKER (Kookaburra)
PRICKLY PORKY (Echidna)
STRIPED CHIPMUNK (Walter Wombat)
BOWSER THE HOUND
TOMMY TIT (Oscar the Owl)
HAPPY JACK SQUIRREL (Sugar Glider)

 Picture builder
 Dictionary
 Prediction
 Sequencing
 Inference
 Anaphor
 Text detective (literal meanings)

TEXT CODING
Yellow highlights are for the bolded text that comes up as a result of using the hint function.
Green is for words to be incorporated in the dictionary function.
Blue is the picture description to be created in picture builder.

THE ADVENTURES OF BILLY POSSUM

By
Thornton W. Burgess

Adapted by Michelle Somerton
Illustrated by Jason Bugg

I BILLY POSSUM IS CAUGHT

Many animals lived on the peaceful grassy paddocks and in the green forest. Late one day, just as the afternoon shadows fell across the hills, Reddy Fox had some news and was grinning as he told the story.

"Old Billy Possum is dead. I know this because I saw Farmer Brown carrying him home by the tail," said Reddy. "So he wasn't as smart as he thought he was," he said with a smile.

No one really believed Reddy Fox though, as everyone knew that he didn't often tell the truth. When Jimmy Goanna came sadly down the narrow paddock track and said it was true though, they had to believe it. 

Reddy Fox saw …. carrying Billy Possum home by the tail.

Jimmy Goanna
Farmer Brown
all the animals

Then everyone began to talk about Billy Possum and say nice things about him and say how much they had enjoyed having him live in the forest since he had moved from the city. That was, everyone except Reddy Fox. Reddy Fox said that it served him right because he was of no use anyway. Then everyone started to growl and hiss at Reddy until he was happy to just slink away.

But while they were all saying nice things about him, Billy Possum was having an exciting adventure. For once he had been just a bit too bold. He had gone up to Farmer Brown's hen house just before night. Jimmy Goanna had tried to stop him, but he had not listened. Billy Possum said he was hungry and wanted an egg to eat, and couldn't wait until dark to go and steal it. So off he went because Billy Possum was very stubborn. 

It was ….. who tried to stop Billy Possum going to the hen house.

Reddy Fox.
Jimmy Goanna

Farmer Brown

When he got to the hen house he went inside without being seen. All the nests were full of eggs and soon Billy was enjoying his meal so much that he forgot to keep a look out for Farmer Brown. Suddenly, the hen house door opened and in walked Farmer Brown to get some eggs for dinner. There was no time to run and Billy lay as still as if he were dead. When Farmer Brown saw him, he didn't know what to think as he had never seen Billy Possum before. 
Farmer Brown catches Billy in the hen house!

"Well, well, I wonder what happened to this fellow," said Farmer Brown, poking Billy with his toe. He saw some egg on Billy's lips. "Ah ha!" shouted Farmer Brown happily. "So this is the thief who has been stealing my eggs!" He smiled and picked Billy Possum up by the tail and walked towards the house.

As they were passing the wood pile, Farmer Brown dropped Billy Possum on to the wood and picked up some sticks to take home to light a fire. When he turned around again, Billy Possum wasn't there. He put down his sticks and looked everywhere, but Billy Possum was nowhere to be found. 

Farmer Brown picked up some ….. to light a fire.

sticks
eggs
feathers

II REDDY FOX THINKS HE SEES A GHOST

Reddy Fox came down the track and through the forest on his way to the grassy paddocks. He had brushed his red fur until it shone in the sun. His white coat was spotless and he held his big tail in the air so that it did not get dirty. Reddy was feeling as smart as he looked. He would have like to sing, but every time he tried his voice wobbled and he was afraid that someone would hear him and laugh at him. If there was one thing that Reddy Fox did not like, it was being laughed at. 

Reddy Fox had …… fur

red
white
green

Appendix E:

App Intervention – Embedded Strategies

Chapter	Strategy	Example
0	Literal	Example Question #
1	Literal	Reddy Fox saw # carrying Billy Possum home by the tail.
1	Literal	Farmer Brown picked up some # to light a fire
1	Literal	It was # who tried to stop Billy Possum going to the hen house
2	Sequencing	
2	Literal	Reddy Fox had # fur
2	Prediction	
3	Anaphor	It was # who made up his mind to stay
3	Literal	It was # that came up with a good idea
3	Literal	Reddy Fox thought Billy was a #
3	Inference	Jimmy Goanna did not want Billy to leave because: #
4	Prediction	
4	Inference	Billy Possum was now feeling #
5	Sequencing	
5	Inference	Billy Possum was now feeling: #
6	Inference	Sammy Galah # Drummer the Kookaburra to find out Peter Rabbit's secret
6	Anaphor	# saw Peter Rabbit whispering a secret
6	Literal	Sammy Galah wanted to know Peter Rabbit's secret so he asked #
7	Sequencing	
7	Literal	The animals didn't like Sammy, Blacky, Reddy and Shadow because they #

8	Prediction	
8	Literal	Peter Rabbit was excited because #
8	Literal	# were hiding in the hollow log
9	Anaphor	# didn't know that Mr Toad overheard their plans
9	Inference	Prickly Porky was unhappy because he thought #
9	Sequencing	
10	Literal	Shadow and Reddy were laughing because #
10	Inference	Reddy was feeling # with himself
10	Literal	Shadow and Reddy were whispering because they #
11	Prediction	
11	Literal	Peter Rabbit was whispering because #
11	Anaphor	# screeched a warning to the animals
11	Anaphor	It was # who was very, very hungry
12	Literal	Inside the hollow log it was #
12	Sequencing	
12	Anaphor	# knew that Reddy Fox and Shadow the Snake were trapped
13	Prediction	
13	Anaphor	# didn't like to go out in the snow
14	Literal	Mrs Possum had # babies
14	Inference	Mrs Possum was worried because #
14	Sequencing	

15	Literal	Billy Possum could not go to the hen house in daylight because #
15	Inference	Billy decided to sneak out #
16	Inference	Bill Possum was #
16	Sequencing	
17	Prediction	
17	Inference	Billy Possum was feeling very #
17	Literal	Billy Possum felt pleased with himself because #
18	Sequencing	
19	Literal	Billy knew he could get away because #
19	Literal	Billy Possum was worried about #
19	Anaphor	Billy Possum would eat # new eggs
20	Prediction	
20	Anaphor	It was # who was feeling pleased
20	Sequence	
20	Inference	Billy Possum was #
21	Prediction	
21	Inference	Farmer Brown was feeling #
22	Literal	Billy Possum escaped to another hollow tree #
22	Sequencing	
23	Literal	Happy Jack # that Billy Possum was hiding in his old hollow tree
23	Literal	Happy Jack loved the snow because it made him feel #

24	Anaphor	Billy Possum told Happy Jack that # had tried to track him down
24	Literal	Happy Jack and Billy Possum were angry because #
24	Sequencing	
		Mrs Possum was pleased that Billy was safe but was # because he made
25	Inference	her worried
25	Anaphor	It was # who decided to now stay home
25	Literal	The weather was #

- Sequencing options do not appear in spreadsheet but errors are recorded in data.
- Predictions appear in spreadsheet but are not reported in data.
- Student has two attempts at each question if the first response is incorrect. In this case two incorrect responses will be recorded in data against the question.

Appendix F:

Department of Education Tasmania - Approval to Conduct Research

Department of Education
EDUCATIONAL PERFORMANCE SERVICES

2/73 Murray Street, Hobart
GPO Box 169, Hobart, TAS 7001 Australia

Tasmania

File: 1664498

4 March 2013

Michelle Somerton
223 Calder Road
Wynyard, TAS 7325

Dear Michelle

Reading between the lines: Embedding research-based teaching strategies into iPad technology for students with autism.

I have been advised by the Educational Performance Report Committee that the above research study adheres to the guidelines established and that there is no objection to the study proceeding.

Please note that you have been given permission to proceed at a general level, and not at individual school level. You will still need to seek permission from the principal of the school involved in the study.

As discussed on the phone you will need to provide us with a copy of the Good Character Check for your research assistant once this has been established.

A copy of your final report should be forwarded to Educational Performance Services, Department of Education, GPO Box 169, Hobart, 7001 at your earliest convenience and within six months of the completion of the research phase.

Yours sincerely

Tony Luttrell

Manager
(Educational Performance Services)

Appendix G:

Catholic Education Tasmania – Approval to Conduct Research

TASMANIAN CATHOLIC education office

25 March 2014

Ms Michelle Somerton
Faculty of Education
University of Tasmania, Cradle Coast Campus
PO Box 3508
Burnie TAS 7320

Dear Michelle

I am writing in regard to your recent request to conduct the research study; *Reading Between the Lines* in Tasmania's Catholic schools.

I have read the information provided which outlines details of this research project and, subsequently, I am happy to provide in principle approval. Please note however, that it is up to the individual school to determine whether they wish to participate in the study.

Please do not hesitate to contact this office if you require any further information.

Yours sincerely

Dr Trish Hindmarsh
Director

th kk

The D'Arcy Centre PO Box 102 North Hobart 7002 Tel: 03 6210 8888 State Office & Regional Office: South
MacKillop Centre PO Box 160 Riverside 7250 Tel: 03 6327 1795 Regional Office: North
Tenison Woods Centre PO Box 564 Ulverstone 7315 Tel: 03 6425 1603 Regional Office: North West
ceo@catholic.tas.edu.au www.catholic.tas.edu.au Fax: 03 6210 8844

Appendix H:

Principal Information and Consent

P O Box 3508 Burnie
Tasmania 7320 Australia
Phone (03) 6430 4999 Fax (03) 6324 3048
www.utas.edu.au/educ

UTAS

PRINCIPAL INFORMATION SHEET

SOCIAL SCIENCE/ HUMANITITESRESEARCH

Reading between the lines: Embedding research-based teaching strategies into iPad technology for students with autism

Invitation

Your school is invited to participate in a research study which investigates the outcomes of using iPad technology to improve reading comprehension for children diagnosed with Autism Spectrum Disorder. The study is being conducted in partial fulfilment of a PhD degree for Michelle Somerton under the supervision of Associate Professor Ruth Fielding-Barnsley, Dr. Christopher Rayner, and Professor Ian Hay.

1. 'What is the purpose of this study?'

The purpose of this study is to explore the effectiveness of a newly developed iPad 'app' to assist children with autism improve their reading comprehension.

2. 'Why have I been invited to participate in this study?'

Your school has been recommended by North West Learning Services to be eligible to participate in this study as some of your students: (1) have a diagnosis of Autism Spectrum Disorder; (2) are between 9 and 12 years of age; and (3) are reading with reasonable fluency at or around their chronological age.

4. 'What does this study involve?'

The study involves a 10 week intervention employing an 'app' for iPad. This 'app' specifically targets the strategies required to improve reading comprehension. The study requires participants to be assessed on their reading skills, particularly those associated with reading comprehension. The pre-tests will establish the participants' existing reading profiles, and the post tests will measure the changes to existing reading

profiles after employment of the 'app'. These tests would be undertaken at your school within normal school hours and involve a number of standardised reading assessments. The researcher and nominated research assistant are both qualified and registered teachers with 'Department of Education Clearance to Conduct Research in Tasmanian Schools' will conduct both the pre and post reading assessments. An iPad with the 'app' will be provided to participants to enable them to practice the embedded strategies targeted to improve reading comprehension. Participants will be required to use the 'app' twice a week for a period of half an hour each session over the duration of the study. A check-list will be supplied to participants' classroom teachers to enable reporting on general classroom lessons which may specifically target reading comprehension.

It is important you understand that your school, teachers and students involvement is this study is voluntary. While we would be pleased to have your participation, we respect your right to decline. There will be no consequences to you or your school if you decide not to participate. If you decide that your school, teachers or students should discontinue participation at any time, you may withdraw them from the study without providing an explanation. All information will be treated in a confidential manner, and your students' names will not be used in any publication arising out of the research. All of the research will be kept in a locked cabinet in the UTAS office of Ms. Michelle Somerton, and will be securely destroyed five years after publication of the data.

5. Are there any possible benefits from participation in this study?

The intervention employed in this study is designed to improve reading comprehension for all students participating in the research. Although there are no guarantees that these improvements will be noted for all participants, this study will also provide insight into pedagogical approaches applied within educational settings regarding the teaching of students with Autism Spectrum Disorder. This is pertinent particularly with the rapid adoption of iPads and tablet style computing for children requiring additional learning supports.

If we take the findings of this research project and link them with those of other studies, we may gain valuable information for others and it may lead to improvements in the way these approaches to teaching children with autism are used, locally and internationally.

6. Are there any possible risks from participation in this study?

There are no specific risks anticipated with participation in this study other than those associated with the participants' involvement with their regular classroom and school environment. However, if you find that your students or staff are becoming distressed or anxious, the researcher will halt all testing and you will be advised straight away – we could also arrange for counselling or other support through the university, on your request, at no cost to you.

7. What if I have questions about this research?

If you would like to discuss any aspect of this study please feel free to contact either Ms. Michelle Somerton on 0419 601444 or Dr. Christopher Rayner on (03) 6226 2559. Either of us would be happy to discuss any aspect of the research with you. Once we have analysed the information we will follow up with a letter to your school provide you with a summary of our findings. You are welcome to contact us at that time to discuss any issue relating to the research study.

This study has been approved by the Tasmanian Social Science Human Research Ethics Committee. If you have concerns or complaints about the conduct of this study you should contact the Executive Officer of the HREC (Tasmania) Network on (03) 6226 7479 or email human.ethics@utas.edu.au. The Executive Officer is the person nominated to receive complaints from research participants. You will need to quote H12932.

Kind regards

Associate Professor Ruth Fielding-Barnsley, Dip. Ed; B Ed (Spec.Ed), PhD.
Associate Professor – Literacy Education,
University of Tasmania,
Newnham Campus,
Locked Bag 1307,
Launceston Tasmania 7250, Australia

Dr. Christopher Rayner, BSc, BTeach (Hons), PhD
Lecturer in Inclusive Education,
Faculty of Education,
University of Tasmania,
Private Bag 66,
Hobart Tasmania 7001 Australia

Professor Ian Hay, Dip T (NBCAE), BA Psy (UQ), MEd St (UQ), PhD (UQ), MAPS, MACE, FIARLD.
Dean of Education
Newnham Campus,
Building A, Room A 222
Locke Bag 1307,
Launceston Tasmania 7250, Australia

Ms Michelle Somerton, Bed (Hons)
University of Tasmania,
Cradle Coast Campus,
16-20 Mooreville Road,
Burnie Tasmania 7320, Australia

Thank you for taking the time to consider this study.

This information sheet is for you to keep.

CONSENT FORM
Title of Project: *Reading between the lines: Embedding research-based teaching strategies into iPad technology for students with autism*

---

1. I have read and understood the 'Information Sheet' for this project.
2. The nature and possible effects of the study have been explained to me.
3. I understand that the study involves the participation of my school, nominated teachers and students in a research project investigating the outcomes of using iPad and 'app' technology designed specifically to improve reading comprehension.
4. I understand that participation involves no anticipated risks, but that support should be available if participants become distressed as a result of participating, and that the Investigator will be prepared to arrange this support.
5. I understand that all research data, will be securely stored on the University of Tasmania premises for five years, and will then be destroyed.
6. Any questions that I have asked have been answered to my satisfaction.
7. I agree that research data gathered for the study may be published provided that the parents, student, educators/teachers or centre/school are not identified.

8. I understand that the researchers will maintain the confidentiality of all participants and that any information supplied to the researcher(s) will be used only for the purposes of the research.

9. I agree for students and teachers of this school to participate in this investigation and understand that I may withdraw this consent at any time without any effect, and if I so wish may request that any data supplied to be withdrawn from the research.

Name of Centre Manager/School Principal giving consent:

Signature: Date:

Statement by Investigator

☐ I have explained the project and the implications of participation in it to the Manager/Principal and I believe that the consent is informed and that he/she understands the implications of participation

If the Investigator has not had an opportunity to talk to the Manager/Principal prior to them participating, the following must be ticked.

☐ The Manager/Principal has received the Information Sheet where my details have been provided so that they have the opportunity to contact me prior to consenting to participate in this project.

Name of Investigator _____

Signature of Investigator _____ Date _____

Appendix I:

Teacher Information and Consent

P O Box 3508 Burnie
Tasmania 7320 Australia
Phone (03) 6430 4999 Fax (03) 6324 3048
www.utas.edu.au/educ

Faculty of Education

TEACHER INFORMATION SHEET

SOCIAL SCIENCE/ HUMANITITES RESEARCH

Reading between the lines: Embedding research-based teaching strategies into iPad technology for students with autism

Invitation

You are invited to participate in a research study which investigates the outcomes of using iPad technology to improve reading comprehension for children diagnosed with Autism Spectrum Disorder. The study is being conducted in partial fulfilment of a PhD degree for Michelle Somerton under the supervision of Associate Professor Ruth Fielding-Barnsley, Dr. Christopher Rayner, and Professor Ian Hay.

2. 'What is the purpose of this study?'

The purpose of this study is to explore the effectiveness of a newly developed iPad 'app' to assist children with autism improve their reading comprehension.

2. 'Why have I been invited to participate in this study?'

You have been invited to participate as some of your students: (1) have a diagnosis of Autism Spectrum Disorder; (2) are between 9 and 12 years of age; and (3) are reading with reasonable fluency at or around their chronological age.

4. 'What does this study involve?'

The study involves a 10 week intervention employing an 'app' for iPad. This 'app' specifically targets the strategies required to improve reading comprehension. The study requires participants in your class to be assessed on their reading skills,

particularly those associated with reading comprehension. The pre-tests will establish the participants' existing reading profiles, and the post tests will measure the changes to existing reading profiles after employment of the 'app'. These tests would be undertaken at your school within normal school hours and involve a number of standardised reading assessments. The researcher and nominated research assistant conducting the tests are both qualified and registered teachers with 'Department of Education Clearance to Conduct Research in Tasmanian Schools'. They will conduct both the pre and post reading assessments. An iPad with the 'app' will be provided to your students participating in this study to enable them to practice the embedded strategies targeted to improve reading comprehension. These participants will be required to use the 'app' twice a week for a period of half an hour each session over the duration of the study. A check-list will be supplied to you as classroom teacher to enable you to also report on general classroom lessons which may specifically target reading comprehension.

It is important you understand that your involvement is this study is voluntary. While we would be pleased to have your participation, we respect your right to decline. There will be no consequences to you if you decide not to participate. If you decide that you should wish to discontinue participation at any time, you may withdraw them from the study without providing an explanation. All information will be treated in a confidential manner, and your name will not be used in any publication arising out of the research. All of the research will be kept in a locked cabinet in the UTAS office of Ms. Michelle Somerton, and will be securely destroyed five years after publication of the data.

5. Are there any possible benefits from participation in this study?
The intervention employed in this study is designed to improve reading comprehension for all students participating in the research. Although there are no guarantees that these improvements will be noted for all participants, this study will also provide insight into pedagogical approaches applied within educational settings regarding the teaching of students with Autism Spectrum Disorder. This is pertinent particularly with the rapid adoption of iPads and tablet style computing for children requiring additional learning supports.

If we take the findings of this research project and link them with those of other studies, we may gain valuable information for others and it may lead to improvements in the way these approaches to teaching children with autism are used, locally and internationally.

6. Are there any possible risks from participation in this study?
There are no specific risks anticipated with participation in this study other than those associated with your involvement with the regular classroom and school environment. However, if you find that you are becoming distressed or anxious, you may advise the researcher or your school principal. We could also arrange for counselling or other support through the university, on your request, at no cost to you. Contact details for this service in Hobart are (03) 62262697, Launceston (03) 63243787, and Cradle Coast (03) 64304949.

7. What if I have questions about this research?

If you would like to discuss any aspect of this study please feel free to contact either Ms. Michelle Somerton on (03) 6430 4949 or Dr. Christopher Rayner on (03) 6226 2559. Either of us would be happy to discuss any aspect of the research with you. Once we have analysed the information we will follow up with a letter to your school provide you with a summary of our findings. You are welcome to contact us at that time to discuss any issue relating to the research study.

This study has been approved by the Tasmanian Social Science Human Research Ethics Committee. If you have concerns or complaints about the conduct of this study you should contact the Executive Officer of the HREC (Tasmania) Network on (03) 6226 7479 or email human.ethics@utas.edu.au. The Executive Officer is the person nominated to receive complaints from research participants. You will need to quote H12932.

Kind regards

Associate Professor Ruth Fielding-Barnsley, Dip. Ed; B Ed (Spec.Ed), PhD.
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University of Tasmania,
Newnham Campus,
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Building A, Room A 222
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Launceston Tasmania 7250, Australia

Ms Michelle Somerton, B Ed (Hons)
University of Tasmania,
Cradle Coast Campus,
16-20 Mooreville Road,
Burnie Tasmania 7320, Australia

Thank you for taking the time to consider this study.

This information sheet is for you to keep.

CONSENT FORM

Title of Project: *Reading between the lines: Embedding research-based teaching strategies into iPad technology for students with autism*

1. I have read and understood the 'Information Sheet' for this project.
2. The nature and possible effects of the study have been explained to me.
3. I understand that the study involves the participation of me and my students in a research project investigating the outcomes of using iPad and 'app' technology designed specifically to improve reading comprehension.
4. I understand that participation involves no anticipated risks, but that support should be available if participants become distressed as a result of participating, and that the Investigator will be prepared to arrange this support.
5. I understand that all research data, will be securely stored on the University of Tasmania premises for five years, and will then be destroyed.
6. Any questions that I have asked have been answered to my satisfaction.
7. I agree that research data gathered for the study may be published provided that the parents, student, educators/teachers or centre/school are not identified.
8. I understand that the researchers will maintain the confidentiality of all participants and that any information supplied to the researcher(s) will be used only for the purposes of the research
9. I agree to participate in this investigation and understand that I may withdraw this consent at any time without any effect, and if I so wish may request that any data supplied to be withdrawn from the research.

Name of Teacher giving consent: _____

Signature: _____ Date: _____

Statement by Investigator

☐ I have explained the project and the implications of participation in it to the Teacher and I believe that the consent is informed and that he/she understands the implications of participation

If the Investigator has not had an opportunity to talk to the Teacher prior to them participating, the following must be ticked.

☐ The Teacher has received the Information Sheet where my details have been provided so that they have the opportunity to contact me prior to consenting to participate in this project.

Name of Investigator _____

Signature of Investigator _____ Date _____

Appendix J:

Student/Child Information Consent

P O Box 3508 Burnie
Tasmania 7320 Australia
Phone (03) 6430 4999 Fax (03) 6324 3048
www.utas.edu.au/educ

Faculty of Education

Reading between the Lines: Finding out if iPads can help reading.

I understand that I have been asked take part in some research to find out how iPads might help with reading.

I know that I will be doing two lots of reading and word tests at my school with a person who is not my regular classroom teacher.

I know that after doing the reading and word tests I will use an iPad to practice some reading exercises.

I know that using the iPad could help my reading or that it might not.

I understand that if I don't want to do any of the reading and word tests or use the iPads that I can just say so and I won't have to.

I know that if I have questions or worries about doing any of these things I can talk about them with my parents, my teacher, my school principal or anyone at my school.

I understand that no one else apart from my parents, my teacher, and the new teacher doing the reading and word tests will be able to see my tests.

No one else will know that these are my tests.

All of these things have been explained to me and I am happy to participate.

My name is _____

The date is_____

Appendix K:

Parent Information and Consent

P O Box 3508 Burnie
Tasmania 7320 Australia
Phone (03) 6430 4999 Fax (03) 6324 3048
www.utas.edu.au/educ

PARENT INFORMATION SHEET

SOCIAL SCIENCE/ HUMANITITES RESEARCH

Reading between the lines: Embedding research-based teaching strategies into iPad technology for students with autism

Invitation

Your child is invited to participate in a research study which investigates the outcomes of using iPad technology to improve reading comprehension for children diagnosed with Autism Spectrum Disorder. The study is being conducted in partial fulfilment of a PhD degree for Michelle Somerton under the supervision of Associate Professor Ruth Fielding-Barnsley, Dr. Christopher Rayner, and Professor Ian Hay.

3. 'What is the purpose of this study?'

The purpose of this study is to explore the effectiveness of a newly developed iPad 'app' to assist children with autism improve their reading comprehension.

2. 'Why has my child been invited to participate in this study?'

Your child has been invited to participate as they: (1) have a diagnosis of Autism Spectrum Disorder; (2) are between 9 and 12 years of age; and (3) are reading with reasonable fluency at or around their chronological age.

4. 'What does this study involve?'

The study involves a 10 week intervention employing an 'app' for iPad. This 'app' specifically targets the strategies required to improve reading comprehension. Participants will be assigned to either an intervention group using the 'app', or a comparison group not using the 'app'. The reason for having two groups is to measure any improvements in the intervention group using the 'app' and the comparison group

not using the 'app' over the same period of time. The comparison group will be offered the use of the 'app' after intervention group has completed the 8 week period if the 'app' demonstrates positive gains in comprehension. The study requires your child to be assessed on their reading skills prior to, and after the 10 week period. These tests are directly associated with reading comprehension. The pre-tests will establish your child's existing reading profile, and the post tests will measure the changes to existing reading profiles over this period. These tests would be undertaken at your school within normal school hours and involve a number of standardised reading assessments. The researcher and nominated research assistant conducting the tests are both qualified and registered teachers with 'Department of Education Clearance to Conduct Research in Tasmanian Schools'. They will conduct both the pre and post reading assessments. An iPad with the 'app' will be provided to your child to enable them to practice the embedded strategies targeted to improve reading comprehension. Your child will be required to use the 'app' twice a week at school for a period of half an hour each session over the duration of the study.

It is important you understand that your child's involvement is this study is voluntary. While we would be pleased to have your child participate, we respect your right to decline. There will be no consequences to you if you decide not to participate. If you decide that you should wish to discontinue participation at any time, you may withdraw them from the study without providing an explanation. All information will be treated in a confidential manner, and your child's name will not be used in any publication arising out of the research. All of the research will be kept in a locked cabinet in the UTAS office of Ms. Michelle Somerton, and will be securely destroyed five years after publication of the data.

5. Are there any possible benefits from participation in this study?

The intervention employed in this study is designed to improve reading comprehension for all students participating in the research. Although there are no guarantees that these improvements will be noted for all participants, this study will also provide insight into teaching approaches applied within educational settings for students with Autism Spectrum Disorder. This is pertinent particularly with the rapid adoption of iPads and tablet style computing for children requiring additional learning supports.

If we take the findings of this research project and link them with those of other studies, we may gain valuable information for others and it may lead to improvements in the way these approaches to teaching children with autism are used, locally and internationally.

6. Are there any possible risks from participation in this study?
There are no specific risks anticipated with participation in this study other than those typically associated with your child's involvement with their regular classroom and school environment. However, if you find that your child is becoming distressed or anxious, you may advise the classroom teacher, school principal, or researcher and your child can withdraw immediately from the study. Counselling support will be offered through the school social worker/psychologist. We can also arrange for counselling or other support through the University, on your request, at no cost to you. Contact details for this service in Hobart are (03) 62262697, Launceston (03) 63243787, and Cradle Coast (03) 64304949.

7. What if I have questions about this research?
If you would like to discuss any aspect of this study please feel free to contact either Ms. Michelle Somerton on (03) 64304949 or Dr. Christopher Rayner on (03) 6226 2559. Either of us would be happy to discuss any aspect of the research with you. Once we have analysed the information we will follow up with a letter to your school provide you with a summary of our findings. You are welcome to contact us at that time to discuss any issue relating to the research study.

This study has been approved by the Tasmanian Social Science Human Research Ethics Committee. If you have concerns or complaints about the conduct of this study you should contact the Executive Officer of the HREC (Tasmania) Network on (03) 6226 7479 or email human.ethics@utas.edu.au. The Executive Officer is the person nominated to receive complaints from research participants. You will need to quote H12932.

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Thank you for taking the time to consider this study.

This information sheet is for you to keep.

CONSENT FORM

Title of Project: *Reading between the lines: Embedding research-based teaching strategies into iPad technology for students with autism*

1. I have read and understood the 'Information Sheet' for this project.
2. The nature and possible effects of the study have been explained to me.
3. I understand that the study involves the participation of my child in a research project investigating the outcomes of using iPad and 'app' technology designed specifically to improve their reading comprehension. I understand that my child will be assessed on 6 reading tests commonly used in Australian schools, and undertake 1 survey regarding their reading attitudes. I understand that these tests will occur twice over the period of the study. I understand that my child will be using an iPad and 'app' over a 10 week period and will be assigned to either an intervention group a comparison group. If assigned to a comparison group, I understand that my child will be offered the use of the 'app' if the data shows gains in comprehension.
4. I understand that participation involves no anticipated risks, but that support should be available if my child becomes distressed as a result of participating, and that the Investigator will be prepared to arrange this support.
5. I understand that all research data, will be securely stored on the University of Tasmania premises for five years, and will then be destroyed.
6. Any questions that I have asked have been answered to my satisfaction.
7. I agree that research data gathered for the study may be published provided that my child is not identified.
8. I understand that the researchers will maintain the confidentiality of all participants and that any information supplied to the researcher(s) will be used only for the purposes of the research.
9. I agree to participate in this investigation and understand that I may withdraw this consent at any time without any effect, and if I so wish may request that any data supplied to be withdrawn from the research.

Name of Parent/guardian giving consent:

Signature: Date:

Statement by Investigator

☐ I have explained the project and the implications of participation in it to the Parent/guardian and I believe that the consent is informed and that he/she understands the implications of their child's participation

If the Investigator has not had an opportunity to talk to the Parent/guardian prior to them participating, the following must be ticked.

☐ The Parent/guardian has received the Information Sheet where my details have been provided so that they have the opportunity to contact me prior to consenting to participate in this project.

Name of Investigator _____

Signature of Investigator _____ Date _____

Appendix L:

App Comprehension Test created from 1st Chapter of App

THE ADVENTURES OF BILLY POSSUM

By
Thornton W. Burgess

Adapted by Michelle Somerton
Illustrated by Jason Bugg

Many animals lived on the peaceful grassy paddocks and in the green forest. Late one day, just as the afternoon shadows fell across the hills, Reddy Fox had some news and was grinning as he told the story.

"Old Billy Possum is dead. I know this because I saw Farmer Brown carrying him home by the tail," said Reddy. "So he wasn't as smart as he thought he was," he said with a smile.

No one really believed Reddy Fox though, as everyone knew that he didn't often tell the truth. When Jimmy Goanna came sadly down the narrow paddock track and said it was true though, they had to believe it.

Then everyone began to talk about Billy Possum and say nice things about him and say how much they had enjoyed having him live in the forest since he had moved from the city. That was, everyone except Reddy Fox. Reddy Fox said that it served him right because he was of no use anyway. Then everyone started to growl and hiss at Reddy until he was happy to just slink away.

But while they were all saying nice things about him, Billy Possum was having an exciting adventure. For once he had been just a bit too bold. He had gone up to Farmer Brown's hen house just before night. Jimmy Goanna had tried to stop him, but he had not listened. Billy Possum said he was hungry and wanted an egg to eat, and couldn't wait until dark to go and steal it. So off he went because Billy Possum was very stubborn.

When he got to the hen house he went inside without being seen. All the nests were full of eggs and soon Billy was enjoying his meal so much that he forgot to keep a look out for Farmer Brown. Suddenly, the hen house door opened and in walked Farmer Brown to get some eggs for dinner. There was no time to run and Billy lay as still as if he were dead. When Farmer Brown saw him, he didn't know what to think as he had never seen Billy Possum before.

"Well, well, I wonder what happened to this fellow," said Farmer Brown, poking Billy with his toe. He saw some egg on Billy's lips. "Ah ha!" shouted Farmer Brown happily. "So this is the thief who has been stealing my eggs!" He smiled and picked Billy Possum up by the tail and walked towards the house.

As they were passing the wood pile, Farmer Brown dropped Billy Possum on to the wood and picked up some sticks to take home to light a fire. When he turned around again, Billy Possum wasn't there. He put down his sticks and looked everywhere, but Billy Possum was nowhere to be found.

QUESTIONS – FIRST CHAPTER

Reddy Fox was _____ to announce news of Billy Possum's demise even though all

_____ did not often believe him. Jimmy Goanna was sad to hear Reddy Fox's news because he really _____ him and so did all the other animals from the paddocks and forest. They all thought Reddy Fox was _____ because he did not like Billy Possum. It didn't really matter anyway as Billy Possum wasn't really _____ , he was off having his own _____ . Even _____ was not able to _____ him to not go up to Farmer Brown's because Billy was being _____ .

This time Billy Possum could not wait until dark because he was so_____ . When Farmer Brown came in to the hen house, he was _____ to see Billy lying there until he realised that Billy Possum was actually a _____. Farmer Brown felt _____ that he had caught the one who had been stealing his eggs but did not realise that Billy Possum was just _____ he was dead. When he stopped to pick up some sticks from the wood pile, Billy Possum decided it was time to make his _____ .

From reading this text we can see that the paddocks and forest were mostly a _____ place to live. The text suggests that Reddy Fox could not be _____ but Jimmy Goanna always told the _____ because the animals believed him when he told them Billy Possum was dead. We could also say that this was not the _____time that Billy had

_____ eggs, but that this time was Billy was not being _____ which was why he got _____. He was just _____ that this time he was able to escape.

Farmer Brown might have felt a bit _____ when he turned around and discovered Billy Possum had disappeared.

Acceptable Responses to App Comprehension Test

1. excited, pleased, happy
2. (all) the animals
3. liked, loved, admired
4. nasty, mean, not very nice
5. dead
6. adventure, exploit,
7. Jimmy Goanna, Jimmy or Goanna
8. tell, convince, advise
9. stubborn, wilful, headstrong,
10. hungry, starving, famished
11. surprised, startled, amazed
12. thief, robber, crook, stealer
13. happy, pleased, glad, delighted
14. faking, pretending, acting, bluffing
15. escape, break, run
16. peaceful, harmonious, serene
17. trusted, relied on, believed
18. truth, facts
19. first, only, one
20. taken, stolen, pinched
21. careful, alert, wary, attentive
22. caught, captured, seized
23. lucky, fortunate
24. confused, baffled, puzzled

Appendix M:

Reading Attitude Survey

Name_____

School_____ Date of Birth_____

Reading Attitude Survey

How much do you like reading?

Shade in the shapes for how much

	not at all	not much	a bit	a lot
1. On a rainy day?				
2. In school during free time?				
3. At home?				
4. In your free time?				
5. Starting a new book?				
6. In school holidays?				
7. Instead of playing				
8. Different kinds of stories?				
9. On a computer or iPad?				

How do you feel when?

Shade in the shapes for how you feel

	don't like it	ok	happy	very happy
10. Your teacher asks you questions about your reading?				
11. You have to do worksheets about your reading?				
12. You have to read at school?				
13. Reading your school books?				
14. Learning from a book?				
15. It is time for reading lessons at school?				
16. You read aloud in class?				
17. You use the dictionary?				
18. Having a reading test?				

Tick the box for my favourite types of reading are?

- ☐ Story picture books
- ☐ Information books
- ☐ Comics
- ☐ Chapter books
- ☐ Magazines
- ☐ Newspapers
- ☐ Electronic books

Adapted from McKenna & Kear (1990)

Appendix N:

Teacher Check-list

TEACHER CHECK-LIST

MINIMUM TIME ALLOCATED 30 MINUTES TWICE WEEKLY

Participant Name: _____

Sessions	**Week 1** **Day/Time**	**Week 2** **Day/Time**	**Week 3** **Day/Time**	**Week 4** **Day/Time**	**Week 5** **Day/Time**	**Week 6** **Day/Time**
Session 1 **Session 2** **Session 3**						

	Additional activities explicitly supporting reading comprehension
Week 1	
Week 2	
Week 3	
Week 4	
Week 5	
Week 6	

ADDITIONAL TEACHER COMMENTS – ENGAGEMENT, MOTIVATION, ISSUES.

Week 1

Week 2

Week 3

Week 4

Week 5

Week 6