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An Exploration of the Effectiveness of the use of Communication Apps through Mobile Devices on Children with Autism Spectrum Disorders (ASD)

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Declaration

I hereby declare that this is my own work and that it has not been submitted to any other university or higher education institute, or for any other academic award in this institute. Where use has been made of the work of other people it has been fully acknowledged and referenced.

Signed: _____
Date: _____

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Glossary of Abbreviations

Usability Testing	U.T.
Autism Spectrum Disorders	A.S.D.
User Centred Design	UCD
Usability Professionals Association	UPA
UK Council for Health Informatics Professions	UKCHIP
Irish Council for Helath Informatics Professions	iCHIP
Continued Professional Development	CPD
Healthcare Informatics Society of Ireland	HISI
National Disability Authority	NDA
Picture Exchange Communication System	P.E.C.S.
Speech and Language Therapy	S.L.T.
Special Needs Assistant	S.N.A.
Gilliam Autism Rating Scale	GARS
Autism Treatment Evaluation Checklist	ATEC
Action Research	A.R.
Augmentative and Alternative Communication	AAC
Assistive Technology	AT
Department of Education and Skills	DES
Special Education Support Services	SESS
Applied Behaviour Analysis	ABA
Discrete Trial Training	DTT
Hyper Text Mark-up Language	Html
Cascading Style Sheets	CSS
Diagnostic and Statistical Manual Version 5	DSM-5

Dedications

To the young boy who was the inspiration for this research; you not only sparked my interest in the world of Autism Spectrum Disorder (ASD) but unbeknown to you, you were the reason for the development of this research.

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- Kerry Group,
- Ms. Norma Moriarty (Kerry County Councillor),
- Ultron Designs,
- ChatBag,
- Fexco,
- Aspen Grove Solutions,
- OtterBox,

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Abstract

Autism Spectrum Disorder (ASD) is a complex neurological disorder which impacts on people in three primary areas: communication skills, social skills and behaviour skills. The diagnosis of ASD continues to rise with an estimated 1 in 100 receiving diagnoses of ASD in Ireland. There are many interventions promoted on a regular basis that claim positive effects on the basis of empirical research. However, the claims made by such studies are sometimes a little at odds with the level of methodological rigour and/or sample size employed. The research available is based on small scale international studies (America, Canada and Australia); however, they have evidenced the potential benefits being received by participants as a result of utilising this intervention. There are a plethora of Apps available within the ASD sector and particularly within the area of communication.

This research set out to investigate the effectiveness of a communications App based on the Picture Exchange Communication System (P.E.C.S.). While P.E.C.S. was developed for preschool children with ASD, its applicability is not exclusive to this group. Technology is a rapidly growing area and it was inevitable that mobile devices would become part of present and future ASD interventions.

The use of communication Apps and mobile devices with children with ASD is a relatively new and limited area, particularly in Ireland; however, the potential benefits being evidenced highlight its potential for implementation. The development route of the App was of primary concern for the researcher; thus, a multi-disciplinary approach was applied. The methodology adapted to this research was Action Research and User-Centred Design while utilising a mixed-method approach.

The evidence from the research strongly suggests the benefits received by participants as a result of utilising a communication App and mobile device, focuses on five key areas: communication, social inclusion, independence, attention span and behaviours that challenge. This research also highlighted the importance of stakeholder involvement and the requirement for a holistic approach to the intervention to ensure success for participants.

Chapter 1: Introduction & Outline

1.0 Introduction

The aim of this introduction is to provide a brief summary of the structure of the dissertation along with providing a rationale for undertaking this research project. This introduction also presents the research questions that were the primary focus throughout the duration of the research. This chapter begins by discussing the rationale and then progresses to presenting the research questions for the research.

1.1 Rationale

The rationale for this research was twofold; personal and professional. The personal rationale was focused on experience from my social care practice while the second was based on an analysis of the literature. This section begins by first outlining the personal with the professional rationale discussed in the latter of this section.

The inspiration for this research initially began in 2010 when I was on my first practice placement. It was the first time I had met a person with Autism Spectrum Disorder (ASD) and was naturally intrigued with the disorder. Upon observing this person engaging with the iPhone it sparked my interest to explore it further. In 2012, I completed my under-graduate research proposal on the topic of the effects that communication Apps have on children with ASD. As a result of successfully completing this proposal, my supervisor (Dr. Tom Farrelly) and I developed the research proposal to meet a standard suitable to conduct research on with the aim of securing my Masters. I always had a keen interest in technology; however, upon seeing the impact that it had on children with ASD I gained a new found value and respect for its potential and application. It also became clear to me that this was an area with such extensive benefits, yet it remained under research, particularly in Ireland and from the perspective of a social care professional. As a professional in practice, I spend my days engaging with children of varying disabilities one of which is ASD; thus, I am familiar with the broad spectrum of characteristics that it brings. However, this was not being reflected in the literature and current design methodologies for App development. As a result of this, I was in a position of great advantage; I held the knowledge and expertise required to engage in a process that incorporated my professional values as I inherited the role of being a

researcher with a primary qualitative approach. As a result of the above rationale I decided to embark on this journey under the trusted guidance of my supervisors.

The second rationale for this research stemmed from the lack of research in the area; particularly in Ireland. The literature review highlighted several key points and gaps that showed potential for further exploration. These key points included: the lack of Irish research; the design methodologies and the impact that these technologies had on people with disabilities.

The literature evidenced, through the use of small scale studies, the potential that mobile technologies and Apps had on people with ASD, particularly those with ASD. As a result of engaging and implementing these assistive technologies people with ASD were experiencing benefits in the areas of communication, independence, social inclusion, attention span and behaviours that challenge. Even though the evidence available was based on small scale studies and was essentially preliminary the potential that these devices and Apps were having deserved further exploration. It also became evident from reviewing the literature that there was a gap in the voice of the Irish population. The majority of published research conducted in this area took place in America, Canada and Australia. Thus, the applicability of this type of assistive technology to the Irish culture was an area of interest.

Upon reviewing the literature, the design methodologies being utilised were focusing on developing *for* people with ASD as opposed to *with* them. Stakeholders (parents and professionals) were being used as proxies to represent the needs of end users with little or no input being received directly from people with ASD. This analysis resulted in the identification of a gap in the literature and highlighted the need to develop with people as opposed to for them. This identification was the foundation for the development of the design methodologies utilised within this research and continued to be the driving force throughout.

The effects of the use of these communication Apps and mobile devices was an area that required specific investigation. It is all too often that people of vulnerable populations, including parents and professionals, are being exposed to treatments or interventions that are being advertised as evidenced based when in fact there is no

independent evidence surrounding the treatment/intervention. This was particularly evident in the case of the Miracle Mineral Supplement (MMS) treatment that was exposed by Prime Time in 2015 (See section 4.10 for greater detail). The use of evidenced based treatments is essential for people with ASD in order for them to continuously progress. The cost of services is also applicable within this sector as parents and professionals are aware of the high costs of services; thus, they should be provided with transparent and accurate information in order to identify an intervention/treatment that is in the best interest of the child. As a result of engaging in the literature review process it became clear that there is a general consensus that the use of communication Apps and mobile devices result in the improvement of five key areas for children with ASD; communication, social inclusion, independence, attention span and behaviours that challenge.

1.2 Research Aims & Questions

There were two overarching aims for this research which were the guidance for the development of the research questions. The two research aims were: 1) research the effectiveness of communication Apps to enhance the effectiveness of the Picture Exchange Communication System (P.E.C.S.) and 2) drawing on the research to design, test and develop our own App or suite of Apps should a range of Apps prove to be more effective. In order to meet these aims it was essential to develop research questions that were designed to provide answers to the above.

Although not a primary aim of the research, the development cycle undertaken by the researcher which incorporated cross disciplinary methods and knowledge afforded the opportunity to reflect upon and draw out some preliminary thoughts; with regard to the upskilling of social care professionals into the world of App development and health and social care informatics.

Prior to beginning this journey it was essential to set out the primary research questions that would be focused on throughout. We developed six key questions; five of which focused on the effects that the intervention had on the children and the final question focusing on the suitability of the chosen mobile device for children with ASD.

The six research questions were:

1. Do the children use the app more than the folde
2. Does a child with ASD communicate more when using a communication app?
3. Is the child independent in managing the vocabulary library?
4. Is the child engaging in behaviours that challenge less frequently?
5. Is the child engaging more with parents and peers?- social interaction
6. Is the usability of the device suitable for children with ASD?

1.3 Dissertation Outline

In order to investigate these six research questions it was essential to outline a structure that would assist in this process. The method in which this topic was addressed is laid out in the following six chapters.

Chapter two presents the literature review as conducted by the researcher. It comprises of three primary sections which focus on: 1) Autism Spectrum Disorders; 2) Assistive Technology; and 3) the effects that the use of communication Apps have on children with ASD. Section 2.1 provides context to the disorder by outlining a definition and detailing the diagnosis and causes of ASD. This section also discusses the economic and social impact that ASD has on the family and society. Even though there was limited literature available on Ireland and ASD in particular the researcher provided contextualisation by referring to disability as a whole and also referring to the U.K. The symptomology of ASD is presented and is referred to sporadically throughout chapters within the dissertation. This section offers insight into the specific characteristics of people with ASD. This then leads on to a discussion on the sensory processing in children with ASD. This is particularly relevant as every child with ASD is effected by sensory processing in at least one category. Section 2.2 provides an extensive overview of assistive technology while also detailing the Picture Exchange Communication System (P.E.C.S.). Section 2.4 provides an account of the current use of mobile devices and communication Apps on children with ASD with section 2.5 progressing to discuss the effects that these Apps have on the children. The five effects that are discussed include: communication, independence, behaviours that challenge, social inclusion and attention span. Section 2.6 outlines the limitations of the use of these technologies while referring to the device, stakeholders and cost. This section not only presents an account of the

literature to date but it also provides context for the reader when progressing to following chapters.

Chapter three is dedicated to providing an overview and justification of the methodologies used throughout the research. Action research and User Centred Design are discussed along with the mixed methods approach that was utilised for data collection. The tools used for this purpose are also presented which include: focus groups, observations, interviews, questionnaires and the Autism Treatment Evaluation Checklist. This chapter also details the ethics process that was engaged in for the purpose of the research; both for the social sciences and computer sciences. A discussion is presented on the tools that were utilised to facilitate this process including; letters of information, informed consent, etc.

The process of this research was of equal importance to the outputs and consequently deserved a chapter in its own right. Chapter four continues with the ethos of design methodologies by providing an extensive account of the User Centred Design process that was undertaken. This chapter was essential in order to present the steps that were required in order to adapt the framework to develop a tool that created a multi-disciplinary approach. The journey that the researcher took to become an interdisciplinary professional is presented along with a discussion and justification on the features of the App that were included and excluded.

Chapter five presents the results and findings that were generated as a result of adapting a mixed methods approach. This is an extensive chapter; however, it was necessary in order to do justice to the results gathered and also to give voices to the range of participants and stakeholders who were involved in the study. Your attention is also drawn to the appendices attached throughout this chapter which are supplied to provide a greater detail of depth. This chapter presents the results in the form of formative and summative testing while also presenting them in chronological order of use.

Chapter six, while drawing on the issues highlighted in chapter two, provides a discussion and exploration of the issues raised from the findings of chapter five while focusing on answering the six research questions presented above. The researcher also discusses the interdisciplinary design and stakeholders as barriers to implementation within this chapter.

Chapter seven is the final chapter and provides a conclusion to the whole study along with recommendations for research going forward. Contained within the chapter and drawing on the findings and discussion chapters; the dissertation concludes with five recommendations for consideration for other researchers going forward in the area of health and social care informatics.

In conclusion, the research has developed seven chapters that aim to provide a context to the research along with answering the research questions as set out at the beginning of this chapter. In order to provide a context to the research chapter two is presented in the form of the literature review. This chapter outlines and presents and extensive overview of the research currently available within the area mobile devices and communication Apps for people with disabilities.

Chapter Two – Literature Review

2.1 Chapter Introduction

This literature review was undertaken with the aim of providing an extensive overview of topics that would provide context for future discussions in this dissertation. The literature review was designed so as to investigate the current status on the effects of the use of communication Apps through mobile devices on children with Autism Spectrum Disorders (ASD). In order to provide an effective overview of this topic the researcher explored three key themes in depth; Autism Spectrum Disorder, Picture Exchange Communication System (P.E.C.S.) and the current use of Assistive Technology (A.T.) and communication Apps for children with ASD.

Section 2.2 focuses solely on Autism Spectrum Disorders (ASD) and within this section there are six key points of review; diagnosis, gender prevalence, causes, economic and social impact, symptomology and sensory processing. These six topics aim to provide an overview of ASD and provide context for reference going forward.

ASD is a neurological disorder that effects people in three primary areas; social, communication and behavioural skills. ASD is a heterogeneous condition with different aspects effecting different people in different ways. The diagnosis of ASD, in general, occurs early in a child's life and boys are four times more likely to receive a diagnosis compared to girls (Briciet Lauritsen, 2013; Ehlers and Gillberg, 1993). The causes for ASD remain unknown; however, there are potential causes that are highlighted and discussed in this chapter (see section 2.2.3). There is a clear economic and social impact of having a child with ASD. There is little research available in Ireland that specifically relates to ASD; however, research on disability in general has highlighted that there are significant personal costs to raising a child with a disability. This cost is also reflective within society in the form of opportunity cost (see section 2.2.4). In light of the above topics and when designing technology with children with ASD their symptomology is a key point of exploration. ASD is located on a spectrum; thus, it is essential to explore the potential characteristics of children with ASD prior to engaging in a research project with them. Their sensory processing is of similar importance, due to the fact that each child with ASD is effected by at least one area of sensory processing. The above topics

are explored in detail in section 2.2; however, they are also referred to sporadically throughout the dissertation.

Section 2.3 is dedicated to the exploration of Assistive Technology and communication Apps with a particular focus on the Picture Exchange Communication System (P.E.C.S.). This section identifies three key themes for in depth exploration; the process of P.E.C.S.; the theoretical basis of P.E.C.S. and the cost of implementation.

P.E.C.S. is a form of Augmented and Alternative Communication (AAC) which was developed specifically, but not exclusively, for children with ASD. This system focuses on the use of symbols, images and/or pictures to convey a message. The theoretical basis of P.E.C.S. is underpinned by the works of Skinner (1957) and Applied Behaviour Analysis (ABA). These systems focus on the collection of scientific data to assess a child's progress with an intervention. The use of P.E.C.S. has grown in popularity since its development which can be attributed to its evidenced-based approach along with the research studies available proving its effectiveness. P.E.C.S. is also identified as a low- tech system which implies that it is low cost. Due to the fact that a custom device is not required P.E.C.S. is significantly cheaper than other traditional forms of Assistive Technology (A.T.).

The current use and effects of Assistive Technology (A.T.) and communication Apps on children with ASD is investigated in section 2.4. This section begins by highlighting the limited availability of research along with the small sample sizes being utilised. The remainder of this section focuses on the development routes of current communication Apps along with identifying the categories of communication Apps currently available. The availability of mobile devices was a key aspect for this research; thus, is explored within this section. This section briefly identified the positive effects that communication Apps and mobile devices have on children with ASD.

Section 2.5 explores in detail the effects of communication Apps and mobile devices on children with ASD. The research has shown that there are five primary areas that are impacted upon as a result of using communication Apps and mobile devices. These five areas are discussed in greater detail in sections 2.4.2.1 to 2.4.2.5 and include: communication, independence, behaviours that challenge, social inclusion and attention span. However, with these positives in mind, the limitations of this type of

intervention also requires exploration. As with any intervention, there are limitations; however, they have the potential to be overcome.

In conclusion, this literature review provides an extensive review of available research that focuses on the use of communication Apps through mobile devices with children with ASD. This literature review begins by setting the context of ASD and current systems in place to assist with communication (P.E.C.S.). It is important to understand ASD as a whole prior to discussing interventions that are in place or are evolving within the area of ASD.

2.2 Autism Spectrum Disorder – Section Introduction

This section focuses on providing a clear definition of Autism Spectrum Disorder (ASD) by outlining the main characteristics and diagnostic tools used by professionals. The DSM-5 is the diagnostic tool that was utilised to highlight the characteristics required to receive a diagnosis of ASD. The diagnosis of ASD occurs in early life (Willingham, 2013); however, it can be a lengthy process with some people waiting over a year. Other topics discussed within this section include: gender prevalence and causes of ASD, the economic and social impact of ASD on the family and society, symptomology and sensory processing in children with ASD. The exploration of each area aims to set the context for discussions in later chapters along with addressing current debates in the area of ASD. This section begins by discussing the concept of ASD and the process of receiving a diagnosis.

2.2.1 What is Autism Spectrum Disorder (ASD)?

Autism Spectrum Disorder (ASD) is defined as 'a complex neurological disorder' (Bluestone, 2005, p.10). ASD effects the development of the brain in terms of social, communication and behavioural skills (Irish Autism Action, 2010). ASD is a 'heterogeneous condition'; no two people with ASD have the same profile (Lord et al., 2000, p.355). ASD exists on a spectrum and is now categorised using an umbrella term known as 'pervasive developmental disorders' (Howlin, 2006). As stated by Briciet Lauritsen (2013), ASD 'consists of a group of developmental disorders with symptoms that are seen on a continuum ranging from mild to severe' (p.37). Even though each

person is unique in their characteristics, there are four primary categories that identify the symptoms of ASD. As presented by Polsdorfer (2006) the four categories include:

- Persistent deficits in social relationships.
- Persistent deficits in communication skills.
- Repetitive behaviours and restricted interests.
- Difficulty with sensory input.

These four categories of the symptomology of ASD are discussed in greater detail in section 2.2.5. The identification of possible symptoms of ASD may, if deemed necessary by professionals, lead to the completion of the assessment of need process (Health Service Executive, 2013). HIQA outlines six standards that are essential for the effective application of the assessment of need process (See Appendix A). During the completion of the assessment of needs process, the DSM-5 is utilised as the diagnostics tool for ASD.

The introduction of the DSM-5 (2013), has redefined and re-characterised the diagnosis of ASD (Maenner et al., 2014). This re-characterisation has seen the elimination of Aspergers as an independent and distinct disorder from Autism; however, both are now categorised under the umbrella term 'Autism Spectrum Disorders' (Parry, 2013). The diagnosis of ASD was previously assessed based on three characteristics; however, this changed after the DSM was updated (14 years later) in order to incorporate sociological and cultural changes in society (Briciet Lauritsen, 2013). The DSM-5 has reduced the characterisation of ASD to two domains; social-communication domain and a behaviour domain (see appendix B) (Briciet Lauritsen, 2013). Social- communication focuses on aspects such as verbal and nonverbal communication, the development and sustainability of relationships and limited shared interests (Bluestone, 2005). The behaviour domain focuses on the repetition and restrictiveness of behaviours. Some of these behaviours can include: spinning objects, rigid routines and sensory integration (sensitivity to loud noises, etc.) (The National Autistic Society, 2014). The assessment of each of these areas occurs in the process of diagnosing ASD.

2.2.2 Diagnosing ASD

The diagnosis of ASD occurs early in life (usually before the age of 3); however, this may not be reflective of the timeframe of the onset of the disorder (Briciet Lauritsen, 2013). As stated by Wetherby and Prizant (2000), 'ASD is a developmental disorder that originates prior to birth or in early infancy' (pg. 11). However, waiting times for assessment (up to eighteen months) effect when a child receives the diagnosis even though that child had been experiencing symptoms prior to the diagnosis. For example, a child may display delays in their development prior to their first birthday but may be waiting over 12 months to receive a diagnosis. Even though a diagnosis of ASD can be given by a professional to a child at the age of 18 months or even younger it is not recommended to do so (Center for Disease Control and Prevention, 2014). This is due to the fact that some of the skills being assessed by clinicians would not be present in children prior to the age of two years (Lord et al., 2006). Once a child reaches 2 years of age, an ASD diagnosis given by an experienced professional can be considered as reliable (Wetherby and Prizant, 2000).

A study carried out by Lord et al. (2006), evidenced that children who received a diagnosis of ASD at age 2 had a 67% chance of receiving the same diagnosis at age 9. Therefore, the evidence suggests that diagnostic stability for ASD is high (Lord et al., 2006). As previously stated, the majority of cases the diagnosis of ASD usually occurs before the age of three and prior to beginning formal national school education (Willingham, 2013). However, this is not always the case; some children do not receive a diagnosis until later years (Lord et al., 2006). Research has shown that girls are particularly at risk of this. As stated by Newman (2016), the symptoms of ASD may be more subtle in girls rather than boys; thus, making detections of ASD in girls more difficult. Parents are now focused on receiving early diagnoses as evidence is showing that the earlier the diagnosis the greater benefits the child will receive from early intervention (Baird, Cass and Slonims, 2003).

Recent years have seen an increase in the diagnosis of ASD; with research providing some of the causes for this. Baird, Cass and Slomins (2003), provide three key reasons for the increase in diagnosis: 1. 'changing conceptualisation to a spectrum

rather than a core categorical condition, 2. changes in diagnostic methods and 3. the inclusion of children with disorders such as attention deficit hyperactivity disorder and Tourette's syndrome as also having ASD' (pg. 489). Frith and Happé (2014), attribute the increase in diagnoses to the widening of diagnostic criteria and increased awareness, diagnostic facilities and specialists within the area. As outlined by Rogers (2012), ASD effects 1 in 150 children. However, the statistics show that these rates are growing worldwide on average between 10-17% per year (The Autism Society of America, 2012). The figures showed a prevalence of ASD in 1 in 150 children in 2000 and 1 in 68 children in 2010 (Autism and Developmental Disabilities Monitoring (ADDM) Network, 2014). In light of these figures and taking into consideration the estimated increase per year, interventions for children with ASD are in greater demand so as to provide them with earlier opportunities for further development.

2.2.3 Causes of ASD

There has been much debate in the past over the causes of ASD. Many theories have been proven unsuccessful and controversial. One of the most controversial cases was that of the MMR vaccine. Andrew Wakefield (1998), stated that the MMR vaccine was a contributing factor to the development of ASD in children. In 1998, Andrew Wakefield along with 12 others, conducted a study and concluded that the MMR vaccine resulted in the development of ASD. This study was later proven invalid due to ethical misconduct by Andrew Wakefield (American Academy of Paediatrics, 2014). Ten of the thirteen authors of the study have since retracted the findings of the study. This sparked greater interest in the area and as a result, studies were carried out in the US and Europe. Jain et al. (2015) investigated this occurrence among 95,000 children and the results were consistent with others; these studies did not find any association between the MMR vaccine and ASD.

More recent research has identified two possible reasons for the development of ASD. These two reasons can be categorised into primary and secondary causes (National Health Service, 2013). Primary causes are where there are no underlying factors that would explain the development of ASD. The secondary causes include: genetic pre-disposition and environmental factors (Frith and Happé, 2014). As outlined

by the National Health Service (2013), 90% of cases of ASD are from the primary category. Research (Autism Speaks, 2013), has shown that the development of ASD is as a result of the combination of genetic pre-disposition and environmental factors.

Research into the area of genetic pre-disposition highlights that there are autism susceptibility genes located on certain chromosomes (Landrigan et al., 2012). These genetic pre-dispositions are familial or inherited (Anagnostou et al., 2014). Two large scale studies conducted on siblings with ASD evidenced a recurrence rate of ASD of 19% and 27% (Anagnostou et al., 2014). This has been attributed to Copy Number Variations (CNV). CNV's involve 'relatively large segments of DNA' (Anagnostou et al., 2014). Therefore, CNV's are now associated with the cause of ASD in some families (Anagnostou et al., 2014). However, susceptibility does not mean that ASD will be inherited. Research has shown that heritability is lower than previously anticipation and environmental factors play a greater role in the development of ASD (Anagnostou et al., 2014).

Some of the environmental factors that produce a greater risk of developing ASD include: 'advanced parental age at time of conception (mom and dad), maternal illness during pregnancy and certain difficulties during birth' (Sandin et al., 2014). Difficulties at birth include a lack of oxygen to the baby's brain during the birth process. It is important to recognise that these causes of ASD are not independent. Research has suggested that the cause of ASD is most likely due to the complex interaction of both of these risk factors (Autism Treatment Center of America, 2015). Research has also shown that even though there are risk factors (genetic pre-disposition and environmental) for the development of ASD, they only amount to a small proportion of diagnoses (Anagnostou et al., 2014).

2.2.4 Economic and Social impact of ASD on the family and Society

As outlined by Lord and Bishop (2010), ASD impacts on both the economy and the family. Extensive research (Lord and Bishop, 2010; Ganz, 2007; Kendall et al., 2013) conducted in the United States and the United Kingdom highlights that the cost of looking after a child with ASD is much greater than that of the cost of a typically of

children with disabilities amounts to 6% of Irelands' total population, little attention has been given to the economic cost of raising a child with a disability (Roddy and Cullinan, 2015, cited in Cullinan et al., 2015).

Families of children with ASD experience greater environmental stressors, and greater financial stress as a result of caring for their child with ASD. Research has shown that families of children with ASD are more likely to reduce or give up work compared to families of children with other special needs (Lord and Bishop, 2010). To date there are no Irish figures available that explore the economic impact on families and the society of Ireland of raising a child with ASD. There is limited research available in the area of the cost of disability; however, the cost on society continues to be eliminated. This is a complex area of study with an extensive list of variables (National Disability Authority, 2011). The Growing Up in Ireland survey has examined the association between caring for a child with a disability and socioeconomic outcomes (Roddy and Cullinan, 2012). The socioeconomic outcomes that were examined were participation in the labour market, education, social class and household income. The survey revealed that families with a child with a disability are at greater risk of poverty, the primary carer is more likely to leave the labour force and reject potential work opportunities and is less likely to hold a third level qualification. Even though Irish studies do not yet provide national statistics of the economics of disability it is clear from preliminary evidence that Irish trends are similar to those of the U.K. and the U.S. International studies show that families and people with disabilities are presented with an opportunity cost of reduced or loss of employment (Knapp et al., 2009). This opportunity cost does not only impact upon the person and their family but it also costs society (Inclusion Ireland, 2014). Knapp et al. (2009), provides financial estimates of the opportunity costs for a person with ASD as ranging from £19,785-£22,383 (€24,771-€28,023[1]) per annum. The opportunity cost for parents is not stipulated; as this is dependent on each individual case and is difficult to estimate given the ranging educational and skill level held by parents. The cost of and time spent providing care for their child is also not available as databases did not support collecting this type of information; thus, this is another 'informal' factor that results in opportunity costs for families (Knapp et al., 2009).

[1] As per conversion rates on 04/04/2016

2.2.5 Symptomology

As previously stated ASD is a heterogeneous condition which effects people in a variety of ways. The diagnosis of ASD was traditionally framed around three symptoms known as the 'triad of autism' (Murray et al., 2014). A person was diagnosed with ASD when they experienced impairments in the 'triad of autism' which focused on the areas of communication, social interaction and restrictive and repetitive behaviours (Silverman, 2012). The severity of these impairments is dependent upon the person; thus, this is the reason for ASD being located on a spectrum. This dissertation highlighted earlier that there are many diagnostic tools available to clinicians when assessing for ASD; however, as the DSM-5 is the most widely recognised tool this section use's the DSM-5 as the foundation for discussing symptomology. The re-categorisation of the symptomology of ASD in the DSM-5 brought about a reduction in the number of categories for diagnosis (Bennett and Goodall, 2016). The DSM-5 now focuses on two areas for the identification of ASD's: the social-communication domain and the restricted, repetitive patterns of behaviour domain (Murray et al., 2014).

2.2.5.1 Social-Communication Domain

There are three diagnostic criteria within the social-communication domain. In order for a child to meet this criteria the features must be persistent and applicable across multiple contexts. The three criteria include:

1. Deficits in social-emotional reciprocity which results in a failure to engage in normal back and forth conversation; reduced sharing of interests or emotions and failure to initiate or respond to social interactions (American Psychiatric Association, 2013).

2. 'Deficits in non-verbal communicative behaviours used for social interaction' (American Psychiatric Association, 2013, pg. 50). This can present itself with features such as poor eye contact, body language, gestures and facial expressions (Taylor and Matson, 2011).

3. 'Deficits in developing, maintaining and understanding relationships' (American Psychiatric Association, 2013, pg. 50). Children with ASD may experience

difficulties forming relationships, responding and adjusting to different social situations and a lack of interest in their peers (Kelly, 2008).

A review of literature in the area of symptomology highlights that there are many ways to categorise the features of ASD; however, the themes remain consistent. Taylor and Matson (2011), defines the social-communication domain as having eight elements to meet the criteria for diagnosis; however, they are consistent with the DSM criteria. A child who is experiencing impairments in the domain of social interaction may display behaviours, ranging on a scale from mild to severe (Hopf et al., 2016), such as:

- Seems to be in a world of their own even though they are in a group situation (Grover, 2015),
- Lack of interest in activities or peers that are around them (Taylor and Matson, 2011),
- Not making eye contact with the person they are engaging with (National Health Service, 2016),
- Does not abide by social rules and acts as per their own rules (Kelly, 2008),
- Being indifferent to moments that are happy or sad (Mayo Clinic, 2014),
- Displays extreme levels of emotion with no obvious reason (Grover, 2015).
- Refusing cuddles or hugging someone else with too much force (Grover, 2015).

Above is a conservative list of the behaviours that may be experienced by someone with difficulties with social interaction. The experience of these behaviours is individual with some people displaying none, some or all of the above behaviours. With the social difficulties brings communication impairments. The DSM-5 has clearly identified the diagnostic criteria; however, many theorists provide examples of the behaviours that may occur with this impairment.

Communication impairments link directly to those of social impairments and focus on both verbal and non-verbal communication (Bluestone, 2005). Behaviours in this area may manifest to look like the following:

- Repetition of words without understanding the meaning (Mayo Clinic, 2014),

- Difficulty monitoring the tone and volume of their own voice (Bluestone, 2005),
- Difficulty understanding request, demands or questions (Dryden-Edwards and Shiel, 2015),
- Difficulty understanding jargon, jokes, sarcasm or phrases as they tend to take meanings literally (Centers for Disease Control and Prevention, 2014) and
- A lack of varied, spontaneous and imaginative social play (Taylor and Matson, 2011).

Communication levels among children with ASD vary greatly depending upon the child. Some children with ASD may learn to speak fluently; whereas, other children with ASD may never acquire verbal communication (National Institute on Deafness and Other Communication Disorders, 2012). The Centers for Disease Control and Prevention (2014), state that approximately 40% of children with an ASD do not speak at all. For those that do have the ability to speak, they may not necessarily speak in a manner that is functional. For example, a child may have a condition called echolalia; where they simply repeat what they have just heard. Others may also have difficulty constructing a meaningful sentence with the vocabulary that they do have. For example, if a child says “cookie”, the communicative partner is unsure as to whether the child is telling them that they saw a cookie on the TV. or requesting a cooking. Theorists would have initially thought that at least 50% of children with ASD would never learn to talk; however, more recent research is showing more positive results (Fessenden, 2012). Wodka et al., (2013), evidenced that 372 (70% of their sample) children with ASD learned to use simple phrases as a result of intensive early intervention therapies and 253 (47%) became fluent speakers. This study highlights that children with ASD may have difficulties with communication but this does not mean that it cannot be assisted or improved. The use of intensive therapies and alternative methods of communication are options for children with ASD that would provide them with a functional form of communication. The Picture Exchange Communication System (P.E.C.S.) is one of a series of strategies available to children with ASD (See section 2.3.2). Utilising an approach of early intervention may alleviate some of the symptoms of ASD and may assist people to live

more independent lives in later years; but, there is no cure for these symptoms (Bluestone, 2005).

2.2.5.2 Restricted, Repetitive Patterns of Behaviours Domain

The second domain of ASD diagnosis is restrictive, repetitive behaviours; which as outlined by the DSM-5 involves a diagnostic criteria of the following:

- 'Stereotyped or repetitive motor movements, use of objects, or speech' (American Psychiatric Association, 2013, pg. 50),
- 'Insistence on sameness, inflexible adherence to routines, or ritualised patterns of verbal or non-verbal behaviour' (American Psychiatric Association, 2013, pg.50),
- 'Highly restricted, fixated interests that are abnormal in intensity or focus' (American Psychiatric Association, 2013, pg. 50),
- 'Hyper- or hypo reactivity to sensory input or unusual interest in sensory aspects of the environment' (American Psychiatric Association, 2013, pg. 50).

In order to meet the diagnostic criteria for this section a child must be experiencing behaviours in at least two of the above points. The manifestation of restrictive, repetitive behaviours is heterogeneous; thus, it is difficult to derive a definitive list of behaviours (Lidstone et al., 2014). These behaviours are located on a spectrum ranging from lower order to high order (Harrop et al., 2013). The lower order behaviours involves repetitive motor actions and manipulation of the physical or sensory status of an object; for example, hand flapping or spinning objects (Harrop et al., 2013). The higher order behaviours include insistence on sameness and routine, for example, placing objects in a particular pattern or sequence or carrying out their breakfast routine in the exact same manner every morning (Szatmari et al. 2006; Turner 1999). Some of the other restrictive, repetitive behaviours that would be included within this category are:

- Self-injurious behaviours, for example, head banging (Grover, 2015),
- Turning off the lights in a house in a particular order each time (Taylor and Matson, 2011),
- Getting upset when items have been rearranged, for example, living room furniture (Harrop et al., 2013),

- Getting upset if a parent takes a new route to a destination (Ray-Subramanian and Weismer, 2012),
- Sniffing objects, for example, toys (Boyd et al., 2009),
- Rocking (Harrop et al., 2013)
- Difficulties transitioning from one activity/environment to another (Boyd et al.2009),
- Tapping different surfaces (Grover, 2015).

Research (Lopez et al., 2005) has shown that when children with ASD engage in restrictive, repetitive behaviours that it is due to sensory stimulation; be it over or under stimulation. Engagement in these types of behaviours is associated with their management of the sensory stimulus (Baker et al., 2008; Kinsbourne, 1980; Ornitz & Ritvo, 1976; Zentall & Zentall, 1983).

2.2.6 Sensory processing in Children with ASD

Sensory processing (also known as Sensory Integration), is defined as 'the way the nervous system receives messages from the senses and turns them into appropriate motor and behavioural responses' (Sensory Processing Disorder Foundation, 2015, pg.1). People who encounter difficulties in relation to sensory processing may be under or over sensitive to sensory stimulation or sensory-seeking in areas such as: tactile, vestibular, proprioceptive, auditory and visual (Hatch-Rasmussen, 2015; Sensory Processing Disorder Foundation, 2015).

Dr. A. Jean Ayres (2015), identifies tactile, vestibular and proprioceptive sensory stimulation as three areas that are less popular than auditory and visual sensory stimulation but they are crucial to our basic survival. Tactile, vestibular and proprioceptive sensory stimulation assist people in evaluating their environment and developing protective responses for survival (Hatch-Rasmussen, 2015).

Tactile sensory processing refers the nervous system under the skin that sends information to the brain in relation to touch and pressure (Hatch-Rasmussen, 2015). Tactile defensiveness can affect a person's ability to interact with people as difficulties in this area may result in a person becoming overwhelmed by or fearful of certain social interactions (Lane et al., 2009). A person who is tactile defensive may display some behaviours similar to the following:

- withdrawal from touch,
- avoidance of certain foods as a result of the texture,
- avoidance of getting dirty (e.g. mud on their hands),
- disliking to washing their hair or face and using their fingertip as opposed to full hand when playing with or using objects,
- intolerance to wearing certain clothing textures,
- intolerance to the seams on socks and tags on clothes

(Sensory Processing Disorder Resource Center, 2015).

The vestibular system refers to the inner ear and how a child processes body movement and spatial orientation (Vestibular Disorders Association, 2015). Sensitivity in this area can lead to a fear within spaces. Children with this sensitivity may present in two types: having a fear of swings, slides or inclines and seeking intense sensory movement in the form of rocking, spinning, jumping or body whirling (Packer, 2009).

Proprioceptive sensory processing refers to how a child receives stimulus information in the area of their muscles, joints, tendons and connective tissue (Buerger, 2008). This type of sensory dysfunction can manifest itself by a child appearing "clumsy". A child may have difficulty in relation to:

- Motor planning: actively identifying what each part of the body needs to do in order to complete a task; typically developing individuals complete this subconsciously.
- Motor control: connecting the brain to physical movements.
- Grading movement: identifying the level of pressure needed within the limbs to complete a task e.g. holding a cup.
- Postural stability: ability to maintain postural stability and response.

(Sensory Processing Disorder, 2015)

Tomcheck and Dunn (2007), identify auditory processing as one of the most commonly reported areas of sensory processing impairments. Auditory processing can be a particular challenge for children located on the ASD spectrum and may present itself in the following ways:

- Sound sensitivities: hypersensitivity to sound which triggers a 'fight or flight' response and the auditory system remains on high alert.
- Sound discrimination: difficulties interpreting phonemes and tone of voice which creates difficulties in the comprehension of language.
- Filtering background noises: this results in distraction and difficulties processing information.
- Temporal processing: 'understanding the timing and pattern of sound' in order to understand rhythm and language.
- Auditory cohesion: aids in the comprehension of communication.
  (Heath, 2012).

Studies have identified auditory processing as affecting 100% of children with ASD (Greenspan and Weider, 1997). Another more common sensory processing impairment is in the area of visual processing.

Visual processing refers to attempting to avoid or seek visual stimulation; which can include: avoiding bright light or twisting fingers in front of their eyes (Marco et al., 2012). The avoidance of eye contact and the inspection of objects using peripheral vision has been theorised as a coping mechanism for children with ASD when filtering visual input (Tomchek and Dunn, 2007).

The rates of prevalence of sensory processing impairments in children with ASD varies from 30% to 88% in the literature (Gabriels and Hill, 2007). This variation can be associated to the age of participants at the time of the study and the method of measurement used (Tomchek and Dunn, 2007; Gabriels and Hill, 2007). While keeping in line with a focus on children, the evidence (Tomchek and Dunn, 2007; Tavassoli et al.,2013; Gabriels et al., 2008) has shown that on average three quarters of children with ASD poses sensory processing symptoms (Sensory Processing Disorder Foundation, 2015). The Centre for Autism (2015), reported that 87% of children with ASD have sensory processing difficulties. Tomchek and Dunn (2007), identified that 100% of

children with ASD displayed at least 1 of the 10 symptoms associated with sensory processing; with 96% of children reporting difficulties in multiple domains (Marco et al., 2012). Thus, it is clear from the evidence that the acknowledgement of these sensory processing impairments is essential when engaging with children with ASD. Marco et al. (2012), states that as a result of sensory stimuli, children with ASD who have communication difficulties are more likely to engage in self-injurious behaviours and behaviours that challenge. This is as a result of the combination of sensory overload and the lack of a functional form of communication (Marco et al., 2012).

In conclusion, children with ASD are most likely to be affected by sensory processing impairments in at least one area of the nervous system. The five areas of sensory processing vary in intensity and can present differently in each child with ASD. The five areas that a child can be affected in are: tactile, vestibular, proprioceptive, auditory and visual. The high prevalence rates clearly evidences the need for the incorporation of this theory into any interventions, including assistive technologies in their various forms, including Apps.

2.3 Assistive Technology and Communication Apps for children with Autism Spectrum Disorder (ASD)

2.3.1 What is Assistive Technology?

Assistive Technology (AT) is defined as 'any kind of technology that can be used to enhance the functional independence of a person with a disability' (The Family Center on Technology and Disability, 2015, pg.1). AT exists on a continuum ranging from low-technology (e.g. P.E.C.S. folder) to high-technology devices (e.g. DynaVox). DynaVox Mayer-Johnson are an AT company that develop and sell speech generating devices (Leibs, 2016). These devices range in price, size and content; they are highly customisable devices. However, they are an expensive AAC method with price ranging from $4,000 (€3630.75) to $18,000 (€16,338.39)[2] (Assistive Technology Lending Center, 2010). Low-technology AT is defined as 'not requiring electrical power, is easy to use, and proficiency is reached easily'

[2] Converted on 23/02/2016 at a rate of $1:€0.91

(Simari, 2015, pg. 7). Cennamo et al. (2012), states that 'low-tech devices are inexpensive tools often lacking moving parts and having limited functionality' (pg.153). Low-technology AT should require little or no training and can include items found in everyday living (e.g. Velcro) (Stokes, 2011). However, as the section on the cost of P.E.C.S. illustrated, this simple dichotomy of high and low technology is not straightforward when it comes to cost. While pictures and Velcro may be relatively cheap, training and opportunity costs can make even 'low'-technology' devices more expensive.

High-technology AT is more complex and expensive (Cennamo et al., 2012) and is defined as 'involving programming, electricity/ rechargeable battery, and extensive training for proficiency (Simari, 2015, pg.7). The aim of AT is to provide people with disabilities with technology that assists in breaking the barriers to inclusion within society; thus, increasing their independence and quality of life (Schwab Foundation for Learning, 2000). The United Nations (UN) Convention on the Rights of People with Disabilities clearly outlines that it is a person's right to have access to an effective means of communication which includes the use of AT (United Nations, 2006):

> *'Communication includes languages, display of text, Braille, tactile communication, large print, accessible multimedia as well as written, audio, plain-language, human-reader and augmentative and alternative modes, means and formats of communication, including accessible information and communication technology' (Article 2).*
>
> *(United Nations, 2006)*

AT comprises of five categories: computers; communication; mobile technology; smart homes and environmental controls and mounting systems (Enable Ireland, 2015). These categories focus on products that are identified within AT as being high-fidelity devices. This section of the literature review aims to explore the use of low- fidelity AT metaphors (P.E.C.S.) through utilising mobile technology. The mobile technologies that were explored included Tablets, iPads and Smartphones. The use of mobile technology and communication Apps (based on P.E.C.S.) is a rapidly growing area; however, the availability of research remains limited and those available are based on small scale studies (Stokes, 2011; De Leo et al., 2010; Winograd, 2010; Harrell, 2010; Ploog et al., 2013). The next section provides the background to the metaphor being used throughout this research (P.E.C.S.) so as to provide context to the discussions going forward.

2.3.2 Picture Exchange Communication System (P.E.C.S.)

2.3.2.1 What is P.E.C.S.?

The Picture Exchange Communication System (P.E.C.S.) is a form of 'Augmentative and Alternative Communication (AAC)'; which uses pictures rather than words to facilitate communication (Overcash et al., 2010). P.E.C.S. was developed in 1985 by Andrew Bondy and Lori Frost (Pyramid Education Consultants, 2007). P.E.C.S. 'is a systematic approach to communication training; using standardised sets of pictographs, communication books and communication boards along with a highly prescriptive teaching manual' (Charman and Stone, 2006, p.242). P.E.C.S. was originally designed for pre-school children with ASD; however, it is not exclusive to this population (Charman and Stone, 2006). P.E.C.S. can be used with any person who has limited speech (Kobza, undated). P.E.C.S. has received recognition across the world for its focus on 'the initiation component' of communication (Pyramid Education Consultants, 2007). The primary goal of P.E.C.S. is to provide children with ASD with 'a fast, self-initiating, functional communication system (National Autism Resources, 2014). P.E.C.S. begins with the exchange of a simple picture with a communicative partner but it quickly begins to focus on the structuring of sentences (Pyramid Education Consultants, 2007).

2.3.2.2 Theoretical Basis of P.E.C.S.

The development of P.E.C.S. is associated to the work of Skinner (1957), where there was an ideology that it is much more productive to 'understand the functional control of verbal behaviour than to focus attention upon its form' (Frost and Bondy, 2002). Thus, the focus should remain on the meaning of the behaviour or the trigger (e.g. pain, tired, hungry) rather than the type of behaviour (e.g. self-injurious, destructive, and aggressive). Skinner (1957) focuses on a theory of operant conditioning in relation to behaviours which holds the ethos that behaviours can be taught through a system of rewards and consequences (Crissey, 2009). As a result of this, P.E.C.S. is taught using a similar approach (See Figure 1). There are six phases of P.E.C.S and they are taught to children with ASD through the theory of Applied Behaviour Analysis (ABA).

ABA is defined as 'the application of the principles of learning and motivation from behaviour analysis (the scientific study of behaviour), and the procedures and technology derived from those principles, to the solution of problems of social significance' (The Centre for Autism and Related Disorders, 2016, pg. 1). ABA is an evidenced-based discipline and is one of the most utilised theories for teaching children with ASD (Morris, 2016). When teaching a child with ASD or implementing an intervention, the professional utilises objective data to assess a child's progress (The Centre for Autism and Related Disorders, 2016). There are five basic principles of ABA which are underpinned by the methodology of Discrete Trail Training (DTT) and this is used to maximise learning (Leaf and McEachin, 1999). The methodology of DTT can be used to develop a variety of skills, such as cognitive, communication and play, and can be applied to various ages and populations (Leaf and McEachin, 1999). The five principles of ABA are: 1) 'breaking a skill into smaller parts; 2) teaching one sub-skill at a time until the person is fluent in the skill and has mastered it; 3) allowing repeated practice in a concentrated period of time; 4) providing prompting and prompt fading as necessary; and 5) using reinforcement procedures' (Leaf and McEachin, 1999, pg. 12). These ABA principles are applied to all six phases of P.E.C.S. and are essential for success when teaching a child how to use this system as a form of functional communication (Frost and Bondy, 2002). An example of the application of prompting during teaching phase I of P.E.C.S. is outlined in figure 1 overleaf.

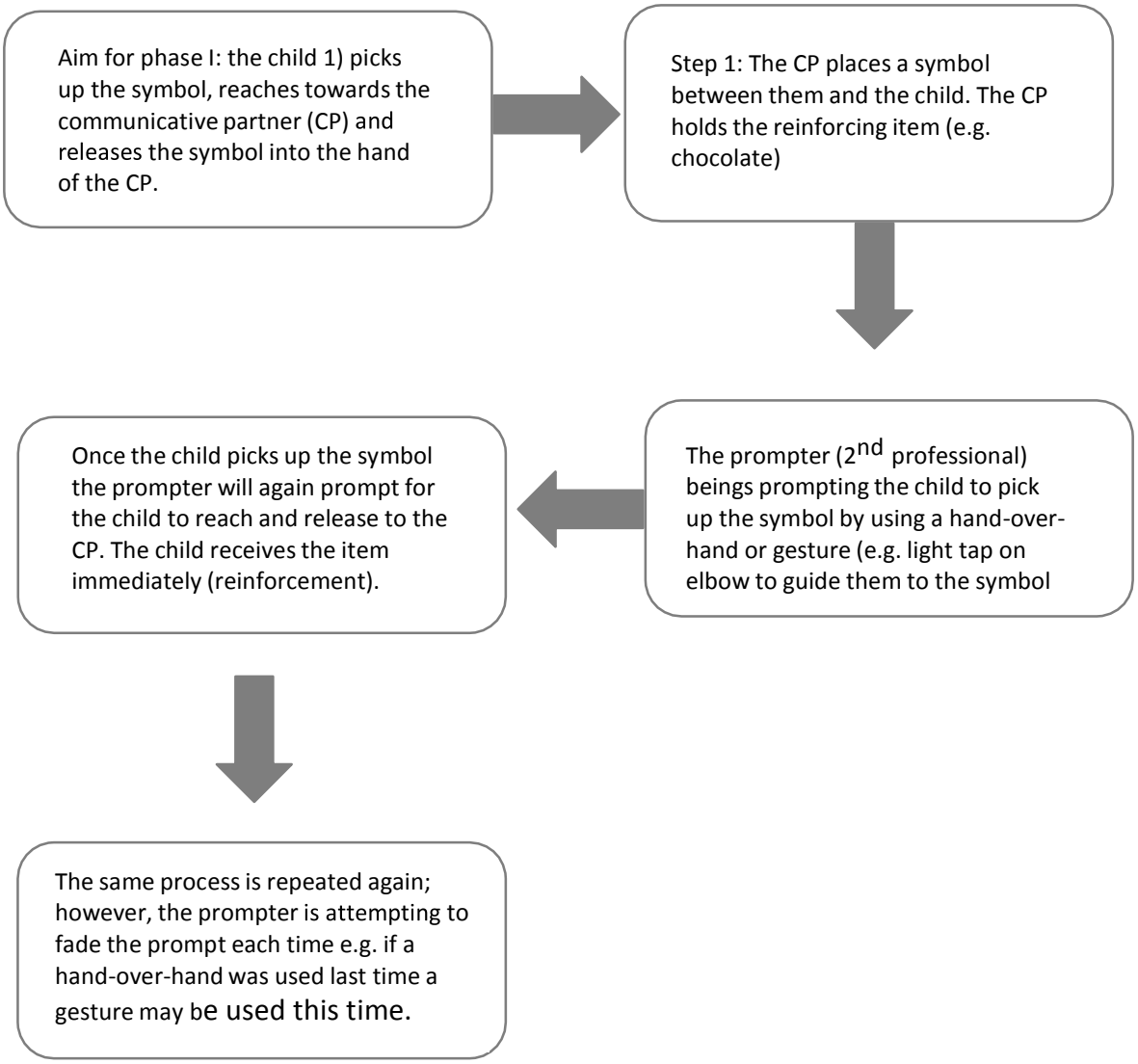


Figure 1ABA Principles applied to P.E.C.S. (prompting as an example)

The purpose of providing the child with prompting is to facilitate the picture exchange (Overcash et al., 2010). These prompts are gradually faded out so that the child is communicating independently (Pyramid Education Consultants, 2007). P.E.C.S. focuses on direct reinforcement in order to provide motivation to communicate (Frost and Bondy, 2012). The reinforcement that a child receives can take on two forms; social and tangible (Frost and Bondy, 2012). The social rewards are based on verbal and physical praise (e.g. “well done” or a “high-five”). The tangible rewards received are the items that the child has requested using the picture exchange system (e.g. chocolate). The application of this theory and these principles is thought to increase the effectiveness of P.E.C.S. (Frost and Bondy, 2002).

2.3.2.3 Is P.E.C.S. effective?

The effectiveness of P.E.C.S. is an issue that requires consideration prior to implementation of an intervention. A systematic review of the effectiveness of P.E.C.S. was conducted on 21 studies (See Appendix C). However, prior to presentation of the finding it is important to highlight that the studies presented are based largely on small samples with the majority being single case studies or small groups. This is a limitation to the available research which is also highlighted by Magiati and Howlin (2003). As a result of the above limitation the search criteria for studies remained broad; however, studies were selected with a particular focus and children and ASD. The consensus of these results evidence that the use of P.E.C.S. is an effective intervention for children with ASD. The children that participated in these studies show particular improvement in the areas of communication and behaviours (Howlin et al., 2007).

The merging of literature evidenced that the increases in communication varied across three key areas: rate of requesting, frequency of exchanges, and initiation. The decrease in behaviours is attributed to the fact that the implementation of P.E.C.S. eliminated the need for behaviours as a function to effective communication (Battaglia and McDonald, 2015). The systematic review clearly evidenced that P.E.C.S. is an effective form for functional communication for children with ASD. However, the successful implementation of P.E.C.S. is dependent upon variables. Two of the most significant variables within this type of intervention are stakeholders and training.

The benefits that children with ASD could receive from P.E.C.S. appear to be dependent upon the teachers and carers who implement the intervention (Jurgens et al., 2012). The standard of delivery is key to the success of the children; however, Howlin et al. (2007), stated that the majority of teachers implementing P.E.C.S. are untrained or have attended brief training sessions. The lack of on-site support and monitoring for teachers is also of key concern for children using this system (Howlin et al., 2007; Magiati and Howlin, 2003). The lack of training and support for teachers and carers who are implementing P.E.C.S. creates the risk of the delivery of an intervention that is at a significantly lower standard than it is intended to be (Jurgens et al., 2012). Therefore, the training of stakeholders prior to implementation is essentially just as important as the implementation of P.E.C.S. with the children. The key to a successful intervention is

dependent upon the flawless implementation of ABA principles and the P.E.C.S. methods

As with any intervention there are both benefits and limitations. Some of the benefits of P.E.C.S. include: pre-requisite skills, positive reinforcement and training. In order for a child to engage in the process of P.E.C.S. they do not require pre-requisite skills such as literacy, eye contact, gestures or verbal imitation (Flippin, Reska and Watson, 2011). Due to the symptomology of children with ASD, some children will have limited skills prior to beginning P.E.C.S. Children with ASD may not have mastered eye contact or verbal imitation prior to beginning P.E.C.S.; however, this will not hinder their opportunity to learn a functional form of communication. Through utilising the P.E.C.S. strategies children with ASD will be prompted through the process and will be prompted to begin the essential component of communication; exchange (Frost and Bondy, 2012). The element of picture exchange is important to encourage interaction and initiation of communication. The fact that pre-requisite skills are not required prior to beginning P.E.C.S. it is a very appealing element as children can be provided with a functional form of communication at a very early age. As discussed in section 2.3.2.2 children were guided to learn the process of picture exchange by using prompts, gestures and shaping. These principles are applied to all six phases of P.E.C.S.

The process of learning the six phases of P.E.C.S. is advanced using positive reinforcement. A child is reinforced using both social and tangible reinforcers. These reinforcers provide the motivation for children with ASD to communicate. The social reinforcers are based on interactions between the communicative partner and the child. When a child successfully completes a task the communicative partner may use a social reinforcer by saying “well done”, “good talking” or by giving the child a “high-five!” A tangible reinforcer is also given and this is the item that the child has just requested using the picture exchange system. The communicative partner may use social and tangible reinforcers in parallel.

In order for parents and teachers to begin using P.E.C.S. with a child they are advised to undergo training. As evidenced in recent studies (Howlin, Wade and Charman, 2007; Jurgens et al., 2012; Magiati and Howlin, 2003) the success of the implementation of P.E.C.S. is impacted upon by stakeholders. As previously stated the lack of training provides a risk of the delivery of inaccurate interventions (Jurgens et al.,

2012). The training is delivered within a 2-day workshop and provides parents and professionals with the skills to implement P.E.C.S. effectively. Even though this course is expensive (see cost in section 2.3.2.4) to attend, it is a time effective way to learn the principles of P.E.C.S. Parents and teachers are given the opportunity to engage in delivering the six phases of P.E.C.S. while on the course; thus, eliminating any fears or anxieties that they may have in relation to teaching their own child/children. Once any fears or anxieties are dealt with, the communicative partner is equipped to provide a functional form of communication to children. Attending this training is not a requirement for teachers working with P.E.C.S. users and is dependent upon teacher initiative. Teachers are also required to apply to the Department of Education and skills for funding, not only for the course, but also for permission for a substitute teacher while they are away training. The Pyramid Education Consultants is the sole provider of P.E.C.S. training and they provide two training courses per year in Ireland (Irish Autism Action, 2010); thus, there are a limited number of attendee spaces available. The process for applying to the Department of Education and skills for approval to attend the course creates an additional barrier as applying through a third party increases the time it takes to secure a place on the course. If demand is high for the course teachers run a high risk of losing out on the opportunity to train as parents and other professionals have the course booked out. This is without a doubt a barrier to access for teachers; however, the lack of training is not the only limitation to P.E.C.S.

Even though P.E.C.S. has proven successful for communication, its limitations are important to recognise and explore. Flippin et al. (2011), identifies two primary limitations to P.E.C.S. which include: the preparation of symbols and pictures are labour intensive and vocabulary is restricted as a result of carrying around a communication book. In order to develop a communication book for a child with ASD a significant amount of time required (See Appendix D). The preparation of symbols and pictures involves: buying P.E.C.S. symbols software or taking personal pictures, printing these symbols/pictures, laminating the symbols/pictures and putting Velcro on each symbol/picture. This is a tedious and time consuming process for both professionals and parents. The development of a child's vocabulary is also restricted in three primary ways: one, the communication book can only hold so many pictures, two, pictures may get lost, and three, parents and professionals are required to pre-empt vocabulary. This

is an increasing concern as the child begins to develop and extend their vocabulary. Thus, the cost of implementing P.E.C.S. is a continuous process for the duration of the use of P.E.C.S. by the individual. As with any intervention cost is of key concern for parents and professionals alike.

2.3.2.4 What is the cost involved to implement P.E.C.S.?

When evaluating the cost of implementing P.E.C.S. it is important to take a holistic approach. The cost of the implementation of P.E.C.S. is not solely based on the materials for the P.E.C.S. folder; other areas require consideration, such as the training costs for parents/staff and the lost opportunity costs for parents and staff. The remainder of this section focuses on the cost of training, materials and time in relation to the implementation of P.E.C.S.

In order to effectively implement P.E.C.S. as a form of functional communication, both staff at school and parents should be trained in the implementation of P.E.C.S (Howlin et al., 2007). The current cost of a P.E.C.S. course for a professional is €400 and for a parent is €220 (as of 04/03/2016). As previously stated, P.E.C.S. courses are only held in specific locations twice a year in Ireland. This course is two days, thus, overnight accommodation is required for the majority of people. This is a hidden expense for people and in particular for parents of children with ASD who already incur extra costs to raising a child with a disability (See section 2.2.4). When attending the course, parents and professional are provided with training materials such as data collection sheets and a training manual (worth €61.62); however, the materials required for the child are an added expense.

The materials required to implement P.E.C.S. are available to purchase from the Pyramid Education Consultants; however, this is not mandatory for success. Parents and professionals can opt to buy generic stationary (e.g. folder); however, a portable size folder is difficult to locate in shops. The majority of folders available in shops are A4 which are cumbersome for children to transport regularly. The official P.E.C.S. communication book is smaller in size; thus, making portability a success. These P.E.C.S. communication folders are available from the Pyramid Education Consultants and cost

from €21.12-€23.33. The development of symbols that meet P.E.C.S. criteria (symbol with corresponding text), is the next concern. In order to print the required P.E.C.S. symbols to teach the child to communicate, specific software is required. 'PICS for P.E.C.S.' is the minimum software required costing €60.46. These symbols then need to be printed, cut out and laminated by teachers and parents. The time it takes to prepare for implementation can be resource heavy. Each picture that the child may require needs to be located on the CD, printed, cut out, laminated and Velcro attached. Each child's vocabulary is individual; thus, this process must be completed for each individual child. This process may take hours to complete for the most basic vocabulary.

In relation to teacher training, the cost is of key concern. The cost of the course is not the only focus; the cost of the teacher being away from the class needs to be considered. This takes the form of monetary but also opportunity costs. The teacher requires payment during training as this is their profession and the substitute teacher is an added cost for the Department of Education and skills. The opportunity cost refers to the children in the class who may be caused upset due to a change in their routine if their regular teacher is away. The symptomology of ASD supports this concern along with the fact that the children may not be familiar with the substitute teacher and as stated by Wakeel et al. (2015), children with ASD prefer interacting with people they know during interventions.

In light of the above evidence it is clear that there are hidden costs to the implementation of P.E.C.S. This literature review has highlighted that the minimum cost[3] of implementing P.E.C.S. is €323.69 (P.E.C.S. course, folder and Pics CD). The cost of resources, such as time, is an element that a price tag cannot be applied to. Even though, P.E.C.S. is advertised as a being "inexpensive" when the cost of materials is evaluated the cost of implementation increases rapidly.

In conclusion, this literature review has clearly evidenced that P.E.C.S. has proven successful in providing people with a functional form of communication. There are limitations to the system; however, these are outweighed by the benefits received by the individual utilising the system. P.E.C.S. is advertised as being "inexpensive", and in perspective to other AAC's, particularly high-tech AAC, it is; however, the system is

[3] All prices received from the Pyramid Education Consultants (2015); website: http://www.pecs-unitedkingdom.com/pricing.php; http://www.pecs-unitedkingdom.com/store/

resource heavy in relation to time and it does require monetary investment. Therefore, the consideration of other options such as mobile devices and Apps is a viable option given the impacts that they are proving to have on children with ASD.

2.4 The current use of mobile devices and communication App on children with ASD

The researcher conducted a review of twenty-five of the most relevant articles to the area (See Appendix E) so as to obtain an overview of the potential benefits of this type of intervention. The results of this review highlighted that there is a consistent trend in the impact and effects that the use of mobile devices and communication Apps have on children with ASD. The areas that a child with ASD can receive benefits in from this intervention include: communication (Sigafoos et al. (2014); McEwen (2014); Ganz et al. (2013); Chien et al. (2015); Alzrayer et al. (2014)), independence (Domican (2015); De Leo et al. (2010); Harrell (2010)), social inclusion (Sigafoos et al. (2014); McEwen (2014); Ganz et al. (2013); Chien et al. (2015); King et al. (2014);, attention span (Ganz et al. (2013); McEwen (2010); Harrell (2010)) and behaviours that challenge (Ganz et al. (2013); McNaughton and Light (2013)). However, the available research also highlighted some limitations. The areas of limitations include: damage or breakage of devices (Chein et al., 2015), battery life of the devices (Campigotto et al., 2013), navigation of the device interface due to difficulties with fine motor skills (Sennott and Bowker, 2009) and distraction from the purpose of the intervention due to the use of technology McNaughton and Light (2013). These benefits and limitations are discussed in greater detail in section 2.5.

Prior to discussing in depth the impact of Communication Apps and mobile technology for children with ASD, it is important to acknowledge that the research available is limited and based on small scale studies.

The limited availability of research can be attributed to the timescale in which these products became available. The first ever iPhone was launched in America and the UK in 2007; however, the device itself had limitations due to its limited functionality (The Telegraph, 2016). The evolution of this technology in time brought about the

development of communication Apps for children with ASD. Marks and Mile (2008), were one of the earlier researchers in this area and researched the use of the iPod as an educational tool for young people with severe intellectual and social disabilities. De Leo et al (2010), were one of the first studies to focus particularly on the use of smartphone technology to improve communication skills with children with ASD. Post 2010 there has been a dramatic increase in the availability of research in this sector. However, the sample size remains small.

Small sample sizes in these research projects can be attributed to the symptomology of children with ASD. Due to the characteristics of ASD (communication and social impairments along with restricted and repetitive behaviours) it is difficult to conduct large scale studies while accommodating the needs of each participant. For example, attention span and communication are of particular concern when conducting research. Children with ASD in general, have shorter attention spans; thus, making it difficult for them to engage in tasks for lengths of time. Also, each child may have varying communication levels or systems and the researcher is required to facilitate the elicitation of feedback and communication from children. As a result of this, the risk of children becoming frustrated or upset during research trials increases; thus, ethics becomes an issue (See section 3.6). Some researchers overcame this obstacle by using parents of children with ASD along with professionals as proxies in the development of these types of technologies (De Leo et al., 2010). However, this brings with it its own limitations (See next paragraph). As previously stated, ASD is a heterogeneous condition; thus, each person on the spectrum is individual along with their ASD characteristics and this requires planning during research. The sample size for this research is discussed in detail in section 3.5. In light of the issues outlined above, the development process of communication Apps requires analysis and discussion.

The Communication Apps that are currently available have been largely been developed by software developers or parents of children with ASD (O' Cionnaith, 2010; Domican, 2011; Voice4u, 2016). There are a number of limitations to these development routes; chiefly these centre on the fact that the software developers independently have little knowledge of ASD or they have developed these Apps on foot of bespoke requests developed at the behest of the parents. Many of these software developers have never worked with children with ASD; therefore, it is difficult for them to build for

the needs of that population (McEwen, 2014). As ASD is a complex disorder, software developers may run the risk of eliminating some of basic requirements for children with ASD (e.g. sensory processing- colour scheme) (The National Autistic Society, 2015). For the software developers that develop in partnership with a parent of a child with ASD, the risks are similar. Instead of designing for the general population of children with ASD, parents design specifically for their own child. Thus, some of the basic requirements are omitted from the design because that specific child doesn't require it. When developing for children with ASD there are certain aspects that need to be considered. These aspects do not affect every child but the general ASD population needs to be accounted and catered for. Two of the primary aspects that need to be considered include: sensory processing and accessibility; these aspects are discussed in greater detail in the usability chapter of the dissertation.

As outlined by Bradshaw (2013), there are seven categories of Communication Apps. The table overleaf identifies and describes each of the seven categories.

Table 1 The seven categories of Communication Apps

Category	***Description***
Text to speech	These Apps convert text to spoken communication and are probably the largest category of apps for communication
Symbols in grid based system	A number of symbols are used within grid systems on the screen, with each symbol activating a spoken word or phrase
Word predictor	These systems have a word predictor so that possible words are suggested when you start typing. These words are then converted into speech
Phrases	Some Apps have set phrases e.g. Apps which have symbol sets of emotions. Some of these have set phrases, whilst others allow phrases to be changed
Eye pointing	These Apps are designed for people who communicate using eye direction. The communication partner then follows the direction of the eye point to the symbol.
Photo story (or visual story)	These offer the ability to take photos, use these in a slide show and then add in speech to tell the story.
Picture Exchange Communication System	Apps which use the P.E.C.S. as a means of communication

In light of reviewing the above figure, this literature review focuses on the use of Communication Apps that are relevant to two categories: Symbols in grid based system and Picture Exchange Communication System. The categorisation of Apps is difficult as Apps range in diversity of the features that

are offered; thus, some Communication Apps overlap into multiple categories (Brady, 2011). As with this research the Apps being focused on are applicable to both categories.

The use of mobile technology as AT is a relatively new area, however, there has been rapid growth in the use of these technologies due to their accessibility (Tahir and Arif, 2014). McNaughton and Light (2013), state that 'we are in the midst of a potential paradigm shift in AAC for people with ASD' (pg. 5) which can be attributed to affordability, portability, social acceptance and ubiquity. Chien et al. (2015), argues that mobile technologies are no longer a luxury item, even for children. It is estimated that by the end of 2015, 80% of the world's population will have access to mobile devices (Tahir and Arif, 2014). The Statistics Portal (2015), evidences that in Ireland in 2014, sixty-five percent of the Irish consumers were Smartphone users and 38% of Irish consumers were Tablet users. The Eircom Household Sentiment Survey (2013), identified that the trends for the use of mobile technologies are on the increase. The survey highlighted that:

- The ownership of Tablets has doubled with an expected figure of 1.2 million Irish people owning a Tablet by the end of 2013.
- The ownership of Smartphones has grown from 39% to 50%, totalling to 1.6 million users in Ireland.
- An Irish home will have access to an average of four mobile devices.

Mobile technologies have proven successful for people with disabilities and in particular for children with ASD. Dynavox (2014), attributes the success of these mobile devices to the facts that children with ASD possess strengths required to use the devices that empowers enhancement of their communication. Some of the strengths of children with ASD include:

(1) they "understand better when they see something versus just hearing it",
(2) they "think in a visual way and recall visual images and memories easily",
(3) they "can understand and benefit from concrete and visual information regarding daily events" and
(4) they "understand environment or activity specific language".

In light of these strengths, the combination of using Communication Apps (AAC) and mobile technologies (AT) is a viable option to enhance communication systems for children with ASD (Bernardini et al., 2014). Even though this is a new area and research is limited, the preliminary results highlight the potential for the use of these technologies on a daily basis.

2.5 Effects of the use of Communication Apps on children with ASD

Research (McEwen, 2014; Bradshaw, 2013; De Leo et al., 2010), has shown that the use of Communication Apps and mobile devices has had a positive impact for children with ASD. The effects of the use of these Apps take on a holistic approach to the child's life; thus, impacting their school, home and community involvement (Sennott and Bowker, 2009; Shah, 2011; Wilson, 2012). Some of the effects identified in the research include: increased communication, increased attention span, increased independence, decrease in behaviours that challenge and an increase in social inclusion (Quillen, 2011; Marks and Milne, 2008).

2.5.1 Communication

'Communication is integral to the ways in which we teach and learn' (Hayes et al., 2010, pg. 674). Therefore, the development of a functional form of communication is essential to the progress of any child. Functional communication is a process that occurs in a real life setting, results in the exchange of ideas and is used spontaneously (Bradshaw, 2013). Functional communication should be 'used to enable the individual to express their wants and needs and to share information' (Light, 1997, pg. 62). The UN Convention on the Rights of Persons with disabilities clearly advocates for the availability of alternative forms of communication for people with disabilities. Children with ASD now have the right to choose their form of functional communication and as outlined in the Convention this is inclusive of AAC (United Nations, 2006). As previously outlined in this dissertation, engaging in functional communication for children with ASD is a consistent challenge.

The implementation of Communication Apps with mobile devices provides children with ASD with a more functional form of communication that is portable and user-friendly (Achmadi, 2010). By using these Apps and mobile devices, children with ASD are provided with an adaptable platform of functional communication. As outlined

by De Leo et al. (2010), children with ASD preferred to communicate using a mobile device as opposed to the traditional method of P.E.C.S. (folder of vocabulary). Harrell (2010), attributes this preference to the theory that children with ASD are visual learners; thus, are naturally attracted to using technology and screens. The behaviour of the technology remains predictable, unlike humans, which assists in eliminating any social anxieties (Bernardini et al., 2014). The evidence from De Leo et al.'s (2010), study supports their argument that the children with ASD preferred to use their own individual images/photos in comparison to the generic symbols; thus, increasing their motivation to communicate. As a result of the preference to communicate using mobile technologies and individual images/photos, children with ASD are at a greater advantage to increase their language acquisition.

2.5.1.1 Language Acquisition

Language Acquisition is defined as 'the process by which humans get the capacity to perceive, produce and use words to understand and communicate' (Ireri et al., 2012, pg.33). There are four pillars for the development of language acquisition as outlined by Acosta (2012), which include:

1. 'Ability- Physiological and cognitive,
2. Interaction- Vocabulary, intonation, repetition and questioning,
3. Motivation- Internal and external and
4. Data- Forms, meaning and function'

   (pg. 4).

Language acquisition is a process that involves learning (which the communicative partner controls) and acquisition (which the child controls) (Acosta, 2012). There are six stages of language acquisition that a child engages in and success of each stage is dependent on each individual child: pre-talking, babbling, one word stage (holophrastic), two word stage, telegraph stage and later multiworld (Kamalani Hurley,
2015) (See Appendix F). Each of these six stages are applicable to the development of communication for a child with ASD who is using a communication App with a mobile device. The use of communication Apps and mobile devices effects language acquisition

for children with ASD in two particular areas: spontaneous communication and verbal abilities.

2.5.1.2 Spontaneous Communication

The literature suggests that as a result of communicating through a mobile device, the instances of spontaneous communication increased among children with ASD (Ganz et al., 2014). This can be associated to their intuitive use of these mobile devices which leads to a motivation to communicate (Bernardin et al., 2014). As a result of being independent of their vocabulary, children with ASD have the ability to use spontaneous communication by taking their own photos and presenting them to a communicative partner (Ganz et al., 2014). Even though a child has access to their P.E.C.S. folder the use of spontaneous communication is restricted if the parent or professional has not pre-empted to include a new picture that the child may require. Therefore, the use of a mobile device provides greater accessibility for a child to develop skills in spontaneous communication (Ganz et al., 2014). Chien et al. (2015), presented evidence that children were more expressive and better able to communicate their needs as a result of the implementation of a communication App. McEwen (2014), highlights that all children that took part in the research gained on an individual level in relation to their communication through using a mobile device and an App. Ganz et al. (2014), identified an increase in the instances of spontaneous communication when children were using mobile devices compared to traditional P.E.C.S. The development of spontaneous communication also refers to the development of verbal abilities. Research (Moses, 2010; The Center for AAC & Autism, 2009; Chien et al., 2015), has shown that communication Apps encourage the development of verbal abilities for children with ASD. The term verbal abilities refers to the development of a child's expressive and receptive language (The Center for AAC & Autism, 2009). The expressive aspect of language focuses on a child's verbal abilities and was an identified area of improvement within this intervention.

2.5.1.3 Verbal abilities

The development of verbal abilities is a realistic goal for children with ASD (National Institute on Deafness and Other Communication Disorders, 2012). As per the P.E.C.S. protocol, children with ASD are encouraged to attempt verbal pronunciations

of requested items with assistance from the communicative partner (Frost and Bondy, 2002). This concept has been adopted by some of the current Communication Apps available by incorporating the use of a voice output for each symbol/picture. The use of this feature resulted in apprehension from both parents and professionals as there was the perception that it would discourage the development of verbal abilities and social interaction (Domican, 2015; Schlosser et al., 2006). This, however, has not been the case. Further research (The Center for AAC & Autism, 2009) has shown that this feature has the opposite effect; children with ASD increased their attempts of verbal abilities as a result of using the voice output on the device. Schlosser et al. (2006), evidenced an 88% success rate in speech development due to the use of voice output. The voice output reinforced the child and encouraged them to attempt verbalising some vocabulary. The consistency within the device provided the children with the social reinforcer that can occasionally be overlooked by a communicative partner (King et al., 2014).

2.5.2 Independence

The use of Apps and mobile devices provide children with ASD with greater independence throughout their home, school and community life. The simplicity and ease of use of these mobile devices provides children with ASD to become confident and independent in managing and developing their own vocabulary within the Communication App (Campigotto et al., 2013). The implementation of these Apps allow for the child to easily add pictures to their library of vocabulary through utilising the devices camera feature (Nagurski, 2010). The child then has the ability to decide what symbols/pictures are important to them for the purpose of communication (Harris, 2011). This in turn increases their motivation to communicate independently. Parents and professionals no longer have to spend hours preparing symbols/images or pre-empting what symbol/image their child might use next; the child is now responsible for their own vocabulary. Frauenberger et al. (2013), outlines that empowering children with ASD to gain more control and shape one's own environment provides for a greater benefit to a person's wellbeing. As stated by Chien et al. (2015), content preparation (symbols/pictures for P.E.C.S. folder) was reduced by 70% as a result of the implementation of a Communication App. This is an empowering step for children with

ASD. The ease of use of these devices is essential for these children as they are visual learners and as visual learners they learn more effectively by doing rather than being told (Shah, 2011). As a result of increased independence in the management of their vocabulary, children with ASD can communicate more effectively; thus, reducing their frustration.

2.5.3 Behaviours that Challenge

The development of behaviours that challenge is a common theme among children with ASD (The National Autistic Society, 2015). This can be attributed to frustration resulting from communication difficulties and motivation to engage in communication (Bradshaw, 2015). As previously stated in section 2.2.5, communication impairment is a key characteristic of ASD; thus, impacting upon the behaviours of the child. The manifestation of frustration when a person cannot communicate effectively, in most cases, results in an outburst of behaviours that challenge (Dador, 2011). As outlined by Shah (2011), a child may make several attempts to communicate; but when a person doesn't understand they may begin to engage in behaviours that challenge. This frustration can be alleviated when using an App and a mobile device as the child has instant access to vocabulary that they require. If a symbol/image is not in their picture library the child can easily access it by taking a picture using the camera function or by accessing it from the internet.

Marks and Milne's (2008), evidence suggests that the use of a mobile device (iPod) was a positive reinforcer to decrease engagement in behaviours that challenge. When the children with ASD were given the prospect of using the mobile device, the rates of their behaviours that challenged decreased (Marks and Milne, 2008). This suggests that children with ASD show preference to using these types of mobile device to communicate (Campigotto et al., 2013; Sigafoos, 2014). If a child consistently engages in behaviours that challenge social inclusion among peers becomes difficult due to physical risks to others. Thus, with a reduction of engagement of behaviours that challenge due to the implementation of a Communication App with a mobile device, children with ASD are provided with the opportunity of increased social inclusion.

2.5.4 Social Inclusion

AAC and AT can be a particularly important component for the inclusion and participation of children with ASD in school and in the community (Sennott and Bowker, 2009). There are two primary reasons for the increase in social inclusion for children with ASD when using mobile devices: one, using the device as a medium to communicate with peers and two, the "cool" factor.

Peer-to-peer communication is a difficult intervention for parents and professionals to support; however, when children with ASD were given mobile devices to communicate, they used the device as a medium to engage and communicate with other children (Hayes et al., 2010). In a study conducted by Campigotto et al. (2013), the results reported an increase in peer-assisted learning i.e. problem solving and helping one another. This is an unusual interaction to observe in a Special Needs classroom and is attributed to the use of the mobile devices (Campigotto et al., 2013). This research highlights that the children were comfortable using the devices; thus, it relieved their anxieties and facilitated peer-to-peer communication and peer learning. Using these devices as a medium also supported children with ASD to learn the social rules among their peer group (McEwen, 2014). The portability of the devices also assisted in facilitating peer learning as this would not have been possible with the use of traditional technologies (e.g. desktop computers) (Chen, 2012). As a result of the increased communication and engagement children with ASD were more accepted by their peers; thus, resulting in greater social inclusion among their peer group.

It is difficult to measure the "cool" factor of the use of these devices as opposed to traditional P.E.C.S.; however, when exploring popular culture it is clear that children are interested in mobile devices that 'fit in with their peers' (Gonzales et al., 2009; Harrell, 2010). Sennott and Bowker (2009), identify that the use of these devices changed expectations; the general public see these devices as common and are therefore less apprehensive about them. The use of traditional AT (e.g. talking laptops, DynaVox) resulted in people with communication difficulties being perceived and treated as "different". The revolution and popularity of mobile devices among children has impacted on the use of this device as it is less stigmatising in comparison to the use of a P.E.C.S. folder (Ganz et al., 2014). The use of mobile devices and Communication

Apps as opposed to a P.E.C.S. folder has also changed engagement among families. As a result of these ubiquitous devices, family members are more enticed to engage with the device; in effect, strengthening their relationship with the child (Chien et al., 2015). These devices are 'attractive, powerful and appealing to their peer group' (Sennott and Bowker, 2009, pg. 140); thus, creating an argument for their implementation.

Buachanan (2010), stated that as a result of using a communication App people with ASD have been empowered to face situations that they would otherwise have not been confident enough to do. The use of a communication App has enabled confidence within people with ASD to break down the barriers to social inclusion (McEwen, 2014). Jamie Knight is a web developer with ASD and highlights that people often say "I could not live without my iPhone"; however, Jamie Knight states that "I could not live independently without my iPhone" (Buachanan, 2010, pg. 1). The implementation of a communication App provides children with ASD with the opportunity to engage with more meaning and depth in their wider community.

2.5.5 Attention Span

As per the symptomology of children with ASD, attention span remains difficult for some children on the spectrum (Wingrad, 2010). Some children with ASD may get distracted by the slightest shadow, sound, etc. thus, requiring greater motivation to re-engage with the task at hand. De Leo et al. (2010), evidenced that as a result of using a Communication App in conjunction with a mobile device, the attention span of children with ASD increased when engaging in academic activities. Harrell (2010), identifies similar increases in attention span with 30 minutes being spent engaging with activities that focus on academic tasks such as: spelling, counting, puzzles and remembering pictures. This increase in attention span can be attributed to the fact that children with ASD are visual learners and they are more motivated by using mobile devices (Kendrick, 2010). This increase in attention span not only increases their motivation to communicate but it also increases their learning.

As stated by Campigotto et al. (2013), students were more motivated and engaged to learn vocabulary when using a Communication App and mobile device. As a result of the learner profile of children with ASD (visual learners), the use of mobile devices provides an interactive and engaging platform for children with ASD to learn in

a more effective manner (Chien et al., 2015; Zhou, 2015). Husni (2013), identified in their study that teachers highlighted the vocabulary learning App as a recommended tool for children with ASD to learn vocabulary (60% of teachers strongly agreed and 40% of teachers agreed).

2.6 Limitations of the use of Communication Apps and mobile devices

As with any intervention there are limitations and the use of communication Apps and mobile devices is no exception. There are three primary limitations to this type of intervention; two of which are related to the device and one in relation to parents and professionals.

2.6.1 Device limitations

The two limitations that need to be considered prior to implementation of this intervention is: size of the device and battery life. Due to the symptomology, some children with ASD may have difficulties with fine motor skills; thus, a Smartphone would be too difficult for them to use. Some children with ASD are unable to point to a small object or press a rigid button on screen (Hayes et al., 2010). However, this can be overcome by using a tablet/iPad and these are available in a variety of sizes ranging from 7 inch to 10.1 inch. The other issue that needs to be considered is the battery life of the device; although Apple iPads are advertised as sustaining 10 hours of battery life (Quillen, 2011). Children with ASD may react negatively if their device suddenly turns off. This can be addressed by ensuring that the child has access to a charger in the most common places i.e. school, home and in the car. Ensuring this wide range of access should assist in preventing any unforeseen shutdown of the devices. This incured an extra cost; however, this was accounted for in the overall costing of the implementation of this type of intervention. The cost of implementation is discussed in greater detail in section 2.6.3.

2.6.2 Additional Support for parents and professionals

One of the biggest obstacles for implementing this type of intervention is the lack of confidence and knowledge that parents and professionals hold in relation to this area. A primary issue highlighted by professionals is that they were unfamiliar with the technology and had to “learn on the fly” (Quillen, 2011). However, not all parents and

professionals have the confidence to “learn on the fly”; thus, the intervention runs the risk of being unsuccessful.

Parents and professionals are important stakeholders and in the majority of cases are the only communicative partners that the child engages with. As outlined by Marks and Milne (2008), teachers require additional supports for the integration of this technology into the lives of children with ASD. The Special Education Support Service (SESS) provide training in the area of assistive technology; however, numbers for the course are low (12 teachers per course) and demand is high. There are also limitations to this as the course outline states that it is limited to just one teacher per school (SESS, 2016). The additional costs to this are also a concern as the teacher needs to be replaced for the duration of the course and the teacher also incurs expenses as a result of attending the course. The courses take place in five locations throughout the country; thus, the majority of teachers would be required to travel and possibly stay overnight. In school training would be a much more viable option for teachers; however, this process has not been mainstreamed to date.

Irish Autism Action ran a short campaign in relation to this; they were successful in their application to the Department of Communication to provide iPad training to beginners (parents/teachers) (Irish Autism Action, 2014). This application was developed in partnership with Autism Support Louth & Meath and was successful under the Benefit IIII heading of the Department (Irish Autism Action, 2014). However, this grant also came with conditions; training had to be completed between October-December 2014 and was limited to 160 participants (Irish Autism Action, 2014). Even though the Government has commenced providing extra resources for this area they appear to be in the initial stages and are sporadic. Even though there is a lack of support for parents and professionals, the Department of Education and Skills (DES) has developed a policy that aims to assist schools in the purchasing of AT.

The DES has a system in place that aims to provide Primary, Secondary and Special Needs Schools with grant aids to facilitate purchasing of AT. This is a rigorous process and requires assessments from multi-disciplinary teams prior to the approval of grants (Department of Education and Skills, 2013). The policy is detailed and very specific as to the type of AT that can be purchased (Appendix G). The types of AT that are approved under this policy include: ‘laptop/tablet computers with associated modified

software, joysticks, keyboards, touch pads'; however, the approval of such devices are dependent on the fact that the child would not otherwise be capable of engaging in the school curriculum without such a device (Department of Education and Skills, 2013, pg.2). The devices that are not funded for using this scheme include: Smartphones, iPhone and iPods (Department of Education and Skills, 2013, pg.6). As a result of this, children with ASD are presented with obstacles to access to acquire a device that holds the potential to impact holistically on their lives.

2.6.3 Cost of Implementation

Prior to the implementation of any intervention the cost is always a concern and in particular in today's economy. AT has traditionally been seen as expensive and unaffordable for the majority of the population that require it. This statement is not without valid evidence. Traditional AT devices can cost anywhere from €1,993.22[4] (Smartbox Assistive Technology, 2015) to €16,079.98[5] (Assistive Technology Lending Center, 2010). The cost of these devices may mean that they are out of the reach of many families who have children with ASD. As stated by Hayes et al. (2010), the programming of these devices occurs on an individual basis and requires 8-10 hours of work. These devices are too complex for parents and professionals and are not practical for daily living (Hayes et al., 2010). The majority of these devices need to be placed on a table and are bulky and difficult to move (Hayes et al., 2010).

The costs of mobile devices are significantly less than traditional[6] AT. These mobile devices can take the form of Smartphones, Tablets or iPads and the chosen device is dependent on the needs of the child. These types of devices vary in cost and range from €69 (Harvey Norman, 2015) to €509 (Apple Inc., 2015). The more expensive models are not essential for use as an AAC; the iPad mini would be more than suffice for this purpose. The iPad mini is currently costing €249 (Apple Inc., 2015) and even with the purchase of a protective case and extra chargers (€13.99-€29.99) the cost is drastically less than that of traditional AT. Even though there is a minimum cost of €300, the implementation of this system is much more cost efficient (in relation to resources, e.g. time, and financially) in comparison to traditional P.E.C.S. and traditional AT. 30%

[4] £1,450.00- currency conversion correct on 01/04/2015
[5] $17,290.00- currency conversion correct on 01/04/2015
[6] Traditional AT refers to the low-technology and high-technology products as discussed previously

of families reported that affordability of these mobile devices was a key influential factor in the decision making process to use these technologies as a form of AAC (Meder, 2012 cited in McNaughton and Light, 2012).

In conclusion, the implementation of these types of interventions are financially viable not only for the families of children with ASD but also for the Government. The Government are currently spending excessive amounts of money per child on A.T. that may not be meeting their needs through a holistic approach. As outlined within this section many traditional A.T. systems are bulky and difficult to transport; thus, the use of these devices across multiple settings remains an issue. The cost of implementation for this type of intervention is significantly lower than the majority of AAC and A.T. devices currently being supplied and the effects of these systems are proving positive for the child; thus, it is an intervention that is viable financially and practically.

2.7 Chapter Summary

In conclusion, the evidence provided highlights that the use of Communication Apps enhances the lives of the user and provides them with greater access to social inclusion in their local communities. Communication Apps provide children with the opportunity to use the device as a medium in order to engage with family, peers and members of the general public. As these devices are seen on a daily basis by people within the general public, they are less discouraged to engage with the mobile device as opposed to traditional AT (Bradshaw, 2013). The use of Communication Apps and mobile devices allow for children with ASD to be provided with a cost-effective, socially acceptable, user-friendly and portable form of functional communication (King et al., 2014). As previously outlined, this intervention is not without its limitations; however, the potential benefits outweigh the limitations. The evidence provided suggests that children with ASD benefit in relation to their communication, attention span, independence, social inclusion and behaviours that challenge. Therefore, the use of communication Apps with children with ASD holds the potential to effect a child's life using a holistic approach. However, the successful implementation of the intervention is dependent upon stakeholders; thus, the methodology of implementation is key. Chapter 3 provides an account of the methodologies used within this research to create a multidisciplinary approach to the intervention.

Chapter 3: Design Methodologies

3.0 Introduction

The aim of this chapter is to outline and discuss the design methodologies that were utilised for the purpose of this research. This chapter incorporates two aspects of discussion in relation to methodologies: the design methodology for the research process and the design methodology for the development of the App. Due to the nature of the research, ethics was of primary concern from the outset; therefore this chapter also outlines the ethics process that was engaged in prior to commencing field research. However, this chapter begins with the overarching design methodology that was utilised for the research.

Prior to finalising a design methodology for any research there are several questions that require consideration and evaluation so as to choose a design that is appropriate and effective. When engaging in these considerations and evaluations the following eight questions are essential:

- 'How a project is to be broken down into stages.
- What tasks are to be carried out at each stage?
- What outputs are to be produced?
- When, and under what circumstances, they are to be carried out.
- What constraints are to be applied?
- Which people should be involved?
- How the project should be managed and controlled.
- What support tools may be utilised'.

(Avison and Fitzgerald, 2003, p.528)

The design methodology that was utilised for the research process was that of Action Research (AR) and User Centred Design (UCD) was utilised for the development of the App. These methodologies endorse principles of mirroring ethos; thus, their implementation is parallel. Even though these two methodologies evidence similar ethos' they are independent in their own merit and are presented accordingly in the following sections. The data collection and analysis phases took on a mixed-method approach. This chapter begins by defining and discussing action research and the

process of user-centred design for the purpose of App development with children with ASD while the latter outlines the ethical approval process that was required prior to engaging in field research.

3.1 Action Research

> 'There is nothing so practical as a good theory'
>
> (Lewin, 1951, p. 169)

Kurt Lewin was the primary pioneer of action research (A.R.) and highlighted a focus on conducting field experiments in order for the theory of the experiments to influence and shape practice (Gustavsen, 2001). Kurt Lewin's primary focus was on empowering minority groups to develop self-esteem, independence, equality and co-operation so that they had the ability and competencies to overcome 'exploitation' experienced within their societies (Lewin, 1946; Borda, 2001). Lewin utilised social science as the 'means to help solve social conflicts' (Adelman, 1993, pg.8). Kurt Lewin emphasised the importance of integrating theory with practice and as a result developed a 'spiral of steps' that depicts the cycle of action research (Smith, 2001, pg.1) (See Appendix H). Each of these steps involves 'planning, action and fact-finding about the result of the action' (Chevalier and Buckles, 2013, pg. 10). This A.R. spiral acts as a guide to the process; however, McTaggart (1996), highlights that this spiral runs the risk of being misused as *the* A.R. template for practice. A.R. adapts the traditional view of research by not only viewing 'university-trained scientists' as the accepted experts of a topic but also taking into account the contributions of end-users, practitioners and stakeholders (Alidou and Glanz, 2015, pg. 32). The A.R. approach to research is focused on 'problem-solving within social and organisational settings' (Smith, 2001, pg.1).

There are many definitions and slight variations of A.R., which are presented below; however, in essence A.R. involves three core activities: 'planning, action and fact-finding' (Coughlan and Brannick, 2010, pg. 7). Coghlan and Brannick (2010), define A.R. as 'a participatory, democratic process concerned with developing practical knowing in the pursuit of worthwhile human process, grounded in a participatory worldview' (pg. 3). A.R. is a reflective design methodology which is commonly used within the healthcare sector (Koshy et al., 2001). Shani and Pasmore (1985), states that A.R. is

'concerned with bringing about change in organisations, in developing self-help competencies in organisational members and adding to scientific knowledge' (pg. 439). Kemmis and McTaggart (1988), define A.R. as 'a form of collective self-reflective enquiry undertaken by participants in social situations in order to improve the rationality and justice of their own social or educational practices, as well as their misunderstandings of those practices and the situations in which the practices are carried out' (pg. 5-6). A.R. is only effective when it is collaborative and each group member provides a critical examination of the topic being explored (Kemmis and McTaggart, 1988). It is clear from the outlined definitions that the main aim of action research is to empower individuals and communities through collaboration and co-inquiry (Alidou and Glanz, 2015). The varying definitions of A.R. are underpinned by characteristics that are essential to engage in A.R.

These characteristics focus on research in action as opposed to research about action, collaborative democratic partnerships and a sequence of events that bring about an approach to solving the problem (Coghlan and Brannick 2010). Four positive outcomes that have been identified as a result of engaging in A.R. are: personal development, improved professional practice, organisational improvements and contributing to the 'good order of society' (McNiff et al. 2002, pg. 8). A.R. bears similar characteristics to other design methodologies (uses knowledge, knowledge and processes); however, it also encompasses its own unique characteristics. Action research is different from other design methodologies (McNiff et al., 2002, pg. 14) as:

- 'It requires action as an integral part of the research process itself,
- It is focused by the researcher's professional values rather than methodological considerations and
- It is necessarily insider research, in the sense of practitioners reaching their own professional actions'

As outlined earlier in this chapter there are many definitions of A.R.; however, they all uphold the same principles. This is also applicable when considering the components required for A.R. to take place. McNiff and Whitehead (2002), Sagor (2000) and Alidou and Glanz (2015), outline their requirements and features of A.R.; however, when they are individually examined each unique set upholds the ethos as outlined by

Kurt Lewin. McNiff et al. (2002), provide an extensive account of the features required in order to engage in A.R. There are 10 features outlined, all of which involve various levels of engagement and analysis. The 10 steps are: 1) 'a commitment to educational improvement, 2) a special kind of research question, 3) putting 'I' at the centre of the research, 4) a special kind of action that is informed, committed and intentional, 5) systematic monitoring to generate valid data, 6) authentic descriptions of the action, 7) explanations of the action, 8) new ways of representing research, 9) validating claims made as a result of the research and 10) making the action research public' (McNiff et al., 2002, pg. 16).

Though, Sagor (2000, pg.1), outlines a simpler seven step process to engage in action research which include:

1. 'Selecting a focus.
2. Clarifying theories.
3. Identifying research questions.
4. Collecting data.
5. Analysing data.
6. Reporting results.
7. Taking informed action'.

Alidou and Glanz (2015), highlight the importance of a similar process to A.R. and define the process as 'defining the problem and question to be addressed, reflect on how to address it, plan a new way of dealing with it, monitor our alternative approach, evaluate our action, communicate the results, and, if they are satisfactory, change the practice' (pg. 32). A.R. in health and social care practice is a relatively new field; thus, researchers and practitioners are adopting the theoretical writing from education (Somekh, 2006).

The drawbacks of a methodology are important to recognise and A.R. is not an exception; however, Koshy (2010), states that 'when you consider action research for the purposes of professional development or improving a situation, it is difficult to list that many disadvantages' (pg. 25). Nonetheless, other theorists present drawbacks and cautions for researchers when considering A.R. as their methodology. Some of the drawbacks include:

1. Participation rates: Not everyone within the population you are studying will want to take part in the A.R. Participation in research involves investing time and energy and some people may not recognise or be aware of the benefits that participation could bring (Bennett, 2004),

2. Barriers to participation: Time is one of the primary concerns for participants involved in A.R. as there is no doubt that due to its iterative ethos participants are involved within numerous stages of the project (Bennett, 2004). Thus, a commitment is necessary and this can be difficult for some populations who are involved.
3. Those from vulnerable populations are busy trying to secure the necessities for daily life and are unable to participate in research (Bennett, 2004). They focus on basic needs and secure them prior to investing in 'extracurricular' activities.
4. Involvement from participants and stakeholders may not always be continuous or predictable. Due to the time involved in A.R. they may experience task exhaustion; thus, reducing participation sporadically throughout the research (Cornwall and Jewkes 1995).
5. The management of expectations: a balance between the generation of interest and buy-in for the research yet ensuring that the researcher is not creating false hope for the outcomes of the research for participants (Pigozzi 1982).
6. Trust between the researcher and participants and stakeholders holds great weight in A.R.; thus, if this is compromised it can impact upon the outcomes. Transparency in the aims, limitations and outcomes of the research assist with developing and maintaining this trust (Somekh, 2006).
7. Lack of understanding about the research evidences in reluctance in participation (St. Denis, 1992). If participants do not understand the aim of the research or their role and what is expected from them it presents in reluctance.
8. Power struggle: The power struggle within organisations or research sites may become evident throughout and if managed incorrectly can have an impact upon the research (Bennett, 2004). There may be participants present who are not comfortable with being empowered to make change and there may be participants in positions of power who are not comfortable allowing others to contribute to decisions; thus, a power struggle evolves (McNiff et al., 2002).

The implementation of measures to assist in overcoming these drawbacks can take the form of ensuring validity. As with any design methodology, while engaging in

A.R. it is essential to ensure validity of information and findings; which can be received through the use of a mixed-method approach.

3.2 Mixed Method Approach

A mixed-method design is the use of both quantitative and qualitative tools in the data collection phase (Creswell, 2003). The use of mixed-methods in social science research has in the past caused controversy. The controversy surrounded this approach as theorists were claiming that researchers were utilising the approach in an ad-hoc manner and without prior consideration to design procedures (Wisniewska, 2011). However, as outlined by the National Science Foundation (2015), this viewpoint has shifted. It is now thought that 'by using different sources and methods at various points in the evaluation process, the evaluation team can build on the strength of each type of data collection and minimise the weakness of any single approach' (National Science Foundation, 2015, p.47). One of the primary advantages of the use of mixed-methods in research is the production of triangulation.

In order to effectively measure the effects of any intervention it is best practice to ensure triangulation of data (Cohen and Crabtree, 2006). Triangulation was first introduced to the world of social sciences by Webb et al. (1966) and involves obtaining data from a range of 'different and multiple sources, using a variety of methods, investigators and theories (Arksey and Knight, 1999, pg. 21). The triangulation of data assists in improving the accuracy of judgements and enriches data collection by sourcing different types of data that bear on the same phenomenon (Bryman, 2015). Triangulation provides research with greater validity and credibility as it is cross verifying the same theories (Cohen and Crabtree, 2006). The purpose of triangulating data is for confirmation and completeness (Arksey and Knight, 1999). As stated by the National Science Foundation (2015), 'quantitative and qualitative techniques provide a trade-off between breadth and depth, and between generalizability and targeting to specific (sometimes very limited) populations' (pg. 43). Thus, for the purpose of exploring the effectiveness of a communication App on children with ASD, this research triangulated the data using a mixed-method approach. The research used two quantitative tools (The Autism Treatment Evaluation Checklist and questionnaires) along with three qualitative

methodological tools (interviews, focus groups and observations). The remainder of this section focuses on the mixed-method tools utilised beginning with the quantitative methods; The Autism Treatment Evaluation Checklist and questionnaires.

3.3 Quantitative Tools

The quantitative tools utilised during this research were devised so as to assess the effects that the intervention had on participants. The researcher utilised the Autism Treatment Evaluation Checklist (ATEC) and questionnaires so as to meet this aim.

3.3.1 The Autism Treatment Evaluation Checklist (ATEC)

The Autism Treatment Evaluation Checklist (ATEC) was developed by Bernard Rimland and Stephen M. Edelson at the Autism Research Institute (Autism Research Institute, 2014) (See Appendix I). The ATEC was designed for parents, teachers and caregivers in order to measure the effectiveness of an intervention (TACA, 2013). Prior to the development of this tool, researchers, practitioners and parents were using diagnostic tools in order to measure the effectiveness of a treatment (Magiati et al., 2011). The types of tools that had been utilised were: The Childhood Autism Rating Scale (CARS), The Gilliam Autism Rating Scale (GARS), The Diagnostic and Statistical Manual of Mental Disorders 5th Edition (DSM-5) and The Autism Behaviour Checklist (ABC) (Autism Research Institute, 2012). While these tools have proven effective for their specific purpose, when used to measure the effectiveness of an intervention they run the risk of providing inconclusive or misleading information (Lord, 1997). The ATEC is comprised of four sections: Communication, sociability, cognitive awareness and behaviour (Geier et al., 2013). This checklist is not copyrighted; thus, it is available free of charge and results are generated immediately online when the forms are submitted (Rimland and Edelson, 1999). The ATEC is based on the ideology that the lower the score, the more effective the intervention has been (Geier et al., 2013). The ATEC is recommended for use with children who are over two years of age and an upper age limit is not defined (Geier et al., 2013). The ATEC has successfully been used by several studies (Jarusiewicz, 2002; Lonsdale et al., 2002; Magiati et al., 2011), to measure the effectiveness of treatments for people with ASD. This research utilised this checklist during the data collection phase and it was conducted with each participant on a fortnightly basis. The

ATEC took approximately 15 minutes to complete on site and a further 15 minutes to input online. The results were immediately generated online and emailed directly to the researcher within 60 minutes. The researcher utilised five assessments for each child (a baseline and four subsequent assessments) which were then combined to receive an average result for each child. The researcher then compared the result to each individual child to their baseline score so as to identify progress, if any (See section 5.3.1).

3.3.2 Questionnaires

Questionnaires are a popular form of data collection, in particular when collecting data that requires standardisation (National Science Foundation, 2015). May (2011), outlines three types of questionnaires: self-completion, telephone and face-to-face interviews. The selection of the most appropriate type to use is dependent on the research question and resources available to the researcher. For the purpose of this research self-completion questionnaires were utilised. These questionnaires can utilise either open-ended or close-ended questions. The use of open-ended questions occurs when a research requires narrative free-flowing information and close-ended questions are generally used when a researcher requires participants to select from predetermined answers (National Science Foundation, 2015). Questionnaires can be used to collect data that measures progress or changes in behaviour (Foddy, 2003). The collection of data to explore progress or changes in behaviour is essential to the ethos of this research and is one of the primary research questions. As stated by Kirklees Council (2015), questionnaires are used as a 'tool' to collect data and information on a specific issue (pg. 1). Questionnaires are most commonly used for five reasons:

1. 'to collect factual information in order to classify people and their circumstances,
2. To gather straightforward information relating to people's behaviours,
3. To look at the basic attitudes/opinions of a group of people relating to a particular issue,
4. To measure the satisfaction of customers with a product or service,
5. To collect "baseline" information which can then be tracked over time to examine changes.'

(Kirklees Council, 2015, pg. 2)

As with any method of data collection there are both advantages and disadvantages. These types of questionnaires are beneficial as they are cheap and people can take their time completing them; thus, reducing any anxieties that may be caused due to face-to-face meetings, and anonymity is ensured for participants (May, 2011). The absence of an interviewer is also beneficial for triangulation as an interviewer's personality or characteristics run the risk of influencing a participants responses (Bryman, 2004). However, there are also some disadvantages, one of which is that it is essential for the questions to be clear, precise and simple as the risk of misinterpretation needs to be removed (May, 2011). The use of self-completion questionnaires also risks receiving incomplete questionnaires; thus, resulting in missing data (Bryman, 2004). The response rate for self-completion questionnaires is a consistent concern and typically averages a response rate of 40%; however, this is also dependent on the interest the participants have in the topic being explored (May, 2011). Mangione (1995), illustrates a classification for response rates to self-completion questionnaires as requiring a minimum of 50% in order for results to be acceptable for analysis. However, Bryman (2004), outlines steps that can be carried out so as to attempt to increase response rates. Some of the steps include: providing transparency about the research (why the participant was selected, the reasons for the questionnaire and any funding or sponsorship that has been received to facilitate the research), provide participants with a stamped addressed envelope, send participants a reminder and make the questionnaire visually appealing for participants (short questions, clear layout, etc.).

The use of questionnaires was applicable to this research in two phases: usability Testing[7] over the summer period (See Appendix J) and the final stages of the data collection phase (See Appendix K). Parents of participants along with classroom teachers, Special Needs Assistants (SNA's) and Speech and Language Therapists (SLT's) were requested by the researcher to complete two questionnaires; one in late October and one in late December. The purposes of these questionnaires were for formative and summative testing.

[7] 'Usability testing is a way to see how easy to use something is by testing it with real users. Users are asked to complete tasks, typically while they are being observed by a researcher, to see where they encounter problems and experience confusion. If more people encounter similar problems, recommendations will be made to overcome these usability issues' (Experience Solutions, 2015, pg. 1)

Parents and professionals (teachers and Speech & Language Therapists- SLT) were offered the opportunity to engage in online usability testing with the App during the summer period so as to continue designing as per user-centred design guidelines (see section 4.1.2). The stakeholders that chose to engage were provided with a questionnaire to complete that led into future developments of the App. Questionnaires were also distributed at the final stage of the data collection phase to parents, classroom teachers and Speech and Language Therapists so as to triangulate the data collected from the ATEC. The questionnaires involved a series of questions, with the majority being closed questions, and focused on the identification of progress made (if any) by the children during the research. Thus, the use of questionnaires in this research is applicable and in parallel with the outlined purpose of questionnaires.

The use of open and closed questions was used for this research so as to attempt to draw on the advantages of each type and reduce the limitations associated with each type of question. With the use of open-ended questions participants are allowed the freedom of responding to questions using their own terms; resulting in the collection of data that the researcher may not have anticipated or thought of (Bryman, 2004). Open questions also empower a researcher to explore a participant's knowledge or understanding of a particular topic. This was particularly applicable to this research as the researcher provided parents, teachers and SLT with the opportunity to present their findings of the effectiveness of the App for the children. Even though open ended questions provide many benefits for researchers, they also come with limitations. Open ended questions are more difficult to code in the data analysis phase, making it more time consuming and potentially inaccurate (Bryman, 2004). In order to ensure that the researcher was gathering data that would answer the research question the number of open questions provided was limited. Open ended questions provide variability when coding the answers; thus, risking the validity of the findings due to measurement errors (Foddy, 2003). These types of questions also require more effort from participants; therefore, are a contributing factor to the decreased response rates (Bryman, 2004).

Closed questions require participants to choose a response from a list provided by the researcher (Denscombe, 2014). These questions are reinforcing for participants

as they are easier and quicker to engage with (Bryman, 2004). Closed questions provide researchers with a structured format for coding responses and enrich the data collected. Data can be compared quickly and efficiently using the coding system derived by the researcher (Bryman, 2015). However, a researcher must ensure that their questions are effective and precise as participants should not be exposed to choices that overlap. If responses overlap participants would be unsure, possibly causing them to select two responses resulting in invalid data that is then treated as missing data (DeVaus, 2014). Accurate use of closed questions can result in the collection of data that is specific and easily compared. Utilising a mix of both open and closed questions can facilitate a researcher collecting enriched data with both depth and breadth (Saris and Gallhofer, 2014). As a result of the benefits and limitations outlined above, the researcher decided to utilise a majority of closed questions for both online U.T. and for gaining feedback on the effectiveness of the App. For the U.T. questionnaire participants were provided with one open question so as to facilitate them to add any other issues that they would like addressed for future developments of the prototype. The feedback questionnaire at the final stages of the data collection phase focused on the use of closed questions; however, stakeholders were again given the opportunity to add additional comments using an open question. As a result of merging the use of open and closed questions the researcher aimed to reduce the limitations associated with each approach to collect data that is reflective of the research question. In order to answer the research questions posed the use of qualitative tools are required.

3.4 Qualitative Tools

As previously outlined, a mixed-method approach to data collection is being adapted; therefore, the use of qualitative methods is imperative. The qualitative tools that were used for the purpose of this research were: semi-structured interviews, focus groups and observations.

3.4.1 Interviews

Interviews are an appealing form of data collection as there is an impression that they are a more simplistic method (Denscombe, 2014). However, this is one of the risks of interviews; they are much more than a conversation (Bell, 2010). Ethical guidelines are particularly important when conducting interviews (Newton, 2010) and

consideration of this is essential in the planning stages of the research. The researcher has the responsibility to obtain informed consent from participants prior to conducting interviews. The purpose of this is not only to protect the participant but also to protect the researcher and create clear guidelines and expectations (Bell, 2010). It is crucial for the researcher to keep the participant informed and remind them that they have the right to withdraw at any time and that their identity would remain anonymous throughout. The researcher followed the above steps prior to conducting interviews.

The use of interviews is not without its limitations; however, it also holds many advantages. Two of the primary advantages of interviews are adaptability and accuracy:

- Adaptability: A skilful researcher should have the ability to be adaptability and therefore, can probe participants to elicit responses and investigate the deeper meaning of responses (Bell, 2010).
- Accuracy: The accuracy of data collection can be increased through using a recording device (Flick, 2007). The researcher has the option to record the interview (with the participants permission); thus, increasing the accuracy of the report compared to relying solely on note taking (Opdenakker, 2006). The researcher; with the permission of the participant, recorded the interviews and also took notes. Note taking was used so as to ensure that all questions were answered and as a backup in case the recording device malfunctioned (Opdenakker, 2006).

Bryman (2001), identifies that some of the disadvantages of interviews include time and analysis. Interviews are a time-consuming method of data collection; thus, when using a mixed-method approach the number of participants is important to consider. A sample from each stakeholder group may be more appropriate (World Health Organisation, 1994). Even though interviews are time consuming to conduct; the transcribing of the interviews must also be considered. The analysis of data is a major concern as it runs the risk of being subjective and biased (Denzin and Lincoln, 1998). The phrasing and wording of questions is essential so as to ensure you are eliciting the correct information from participants (Gibson and Brown, 2009).

For the purpose of this research, semi-structured interviews were utilised (See Appendix L). A semi-structured interview is ‘a structure that enables a researcher to

cover a range of topics systematically and code responses with reference to a uniform framework' (World Health Organisation, 1994, pg. 5). Semi-structured interviews allow for the researcher to prepare a structured list of questions. These questions can be easily circled; thus, recording and data analysis becomes more time efficient (Bell, 2010). The purpose of a semi-structured interview is to explore issues in a standardised manner so as to elicit data that is appropriate for quantitative and qualitative analysis, systematic comparison and testing hypothesis (Bryman, 2004). This research utilised semi-structured in the initial stages. The researcher invited two Speech and Language Therapists (who were based in the school and worked with the participants), four classroom teachers and ten parents to interview. The researcher interviewed the two Speech and Language Therapists, three classroom teachers and one parent. The structure and flow of the interview questions was essential in order to provide clarity to participants. As stated by the World Health Organisation (1994), the flow of questions in an interview should not: 1. inflict a structure that is difficult for the participant to follow, 2. force dramatic shifts in the topic that participants find it difficult or 3. that the flow allows participants to think that their previous responses were not good enough or listened to. The purpose of the interview was to gather information in three key areas: the participant's current use of P.E.C.S., the participants current use of mobile devices and what Apps in particular, if any, did they engage with; thus, this was reflected in the structure of the questions (See Appendix L). The researcher was particularly conscious about making participants feel at ease as it was not to make them feel like they were being examined or tested; this is a common concern with interviews (Newton, 2010). The information gathered from these interviews was used in the development of user requirements and the development of low-fidelity[8] prototypes. These low-fidelity prototypes resulted in the development of the first high-fidelity[9] prototype; which was then demonstrated to parents and professionals at a focus group.

[8] A paper prototype that is 'sketchy and incomplete, that has some characteristics of the target productbut is otherwise simple' (Usability First, 2015)

[9] An interactive prototype that simulates the real system or site's functionality and design details (Usability.gov, 2015)

3.4.2 Focus Group

A focus group is 'a small group discussion focused on a particular topic and facilitated by a researcher' (Seale, 2012). Focus groups highlight the importance of participant interaction while being monitored by the researcher and guided towards discussing particular topics (World Health Organisation, 1994). Focus groups originated in market research in the 1920's and were adopted into social science in the 1940's. Since the 1980's, the use of focus groups has grown rapidly across varying disciplines including: media, sociology, organisational, environmental and health (Seale, 2012). The use of focus groups in the design of technology for children with ASD is on the increase and the depth and breadth of data being collected identifies this tools as both applicable and worth-while.

A key feature of focus groups is that they offer a 'distinctive method for generating qualitative data on the basis of group interaction and discussion' (Seale, 2012, pg. 228). The group adopt the role of analysing and explore the topic by defining and contesting issues through social interaction (Seale, 2012). The sample size for a focus group generally falls between 4-12 participants; however, this is dependent on the area being investigated. For the purpose of this research 10 parents, 4 classroom teachers and 2 SLT's were invited to the focus group. A total of eight stakeholders attended the focus group; thus, making it a valid method of data collection. This focus group was structured (See Appendix M) and lasted one hour and ten minutes.

Prior to being exposed to the App, participants engaged in critically reflecting upon a user scenario. As stated by Idler (2011), a user scenario is 'a short story of a person who visits a website with a certain motivation and a specific goal in mind' (pg.1) (See Appendix N). User scenarios identify the, who, what and why of end-users engaging with the website/App (U.S. Department of Health & Human Services, 2016). User scenarios provide developers with knowledge for input into design and form the basis for future usability testing (U.T.) (Usability Net, 2006). Upon completion of this task stakeholders were allocated into smaller groups in order to allow them to explore the use of the prototype App. The researcher and two supervisors were observing the interactions and capturing data instantly. Participants each had a feedback sheet (See

Appendix O) to fill out at the end of the session that clearly identified potential user requirements. The focus group

provided participants with the opportunity to openly debate and discuss their views in relation to user requirements. This method of data collection provided the researcher with user requirements of greater depth and breadth that would not have otherwise been collected if an alternative method was chosen (See section 5.2.2).

3.4.3 Observations

Denzin and Lincoln (1998), identify observations as one of the earliest and most basic forms of social science research. Morris (1973), defines observation as 'the act of noting a phenomenon, often with instruments, and recording it for scientific or other purposes' (pg. 906). Creswell (2003), identifies observations as being unstructured or semi structured whereby the researcher compiles field notes on the behaviours, activities and actions of participants and stakeholders within the research site. Denzin and Lincoln (1998), outline a key aspect of observation is that the observer neither manipulates nor stimulates its participant. Therefore, the interactions and behaviours recorded by the researcher should be subjective to the presence of the researcher. As outlined by Creswell (2003), there are four main types of observations ranging from complete participant to complete observer; each of which bring advantages and disadvantages. These four types of observation were originally developed by Gold (1958) (Denzin and Lincoln, 1998).

Table 2 Types of observations (Creswell, 2003, pg.186)

Type of observation	**Advantages**	**Disadvantages**
Complete participant: researcher conceals role	Researcher has first-hand experience with participants	Researcher may be seen as intrusive
Observer as participant: role of researcher is known	Researcher can record information as it is revealed	'Private' information may be observed that the researcher cannot report
Participant as observer: observation role secondary to participant role	Unusual aspects can be noticed during observation	Researcher may not have good attending and observing skills

Complete Observer: researcher observes without participating	Useful in exploring topics that may be uncomfortable for participants to discuss	Certain participants (e.g. children) may present special problems in gaining rapport

In light of the above, the researcher adapted the observer as participant type of observation. Within this type of observation the researcher remains research focused and does not cross into the friendship domain with participants or stakeholders (Denzin and Lincoln, 1998). The observations implemented within this research was direct observation; the researcher had direct contact with the participants and recorded observations through field notes (Denzin and Lincoln, 1998). This research utilised standardised observations with the aim of identifying the frequency of behaviours that relate to communication, attention span, independence, social inclusion and behaviours that challenge (Flick, 2011). One of the criticisms of observations relates to their validity; thus, they are generally utilised in conjunction with other tools, such as, interviews (Gibson and Brown, 2009). The use of observations provided the researcher with the opportunity to create triangulation within results and also to collect results that were more accurate and reliable. Due to the heterogeneous nature of ASD it was important for the researcher to know each child individually with observations facilitating this.

3.5 Sample:

The quality of a piece of research is highly dependent on the sample strategy that has been adopted (Cohen, Manion and Morrison, 2007). When making a judgement on a sample strategy it is imperative to consider the sample size, the representativeness of the sample, access to the sample and the sampling strategy to be used (Teddlie and Yu, 2007). The sample size is also influenced by the type of research being undertaken and is dependent on several variables including: time, money, the amount of researchers, ethical guidelines and available resources (Cohen, Manion and Morrison, 2007).

As a result of the considerations outlined above and the nature of this research the sampling strategy that was decided upon was the use of non-probability sampling (Fink, 1995). Non-probability sampling is frequently used in small scale A.R. studies and

focuses on targeting a specific population (Kelly, 2011) that hold particular characteristics. Within non-probability sampling there are several subtypes including: 'convenience sampling, quota sampling, dimensional sampling, purposive sampling and snowball sampling' (Cohen, Manion and Morrison, 2007, pg. 113). This research adapted convenience sampling for the purpose of identifying the research site. Through the researchers practice as a social care professional, Nano Nagle School became a viable option to liaise with. The researcher had links to the school through service users that were engaged with during practice. The researcher was aware of the populations catered for within the school; thus, was aware of the potential to accessing children with ASD.

The sample strategy used for participant recruitment was purposive sampling; which focuses on participants that hold a certain characteristic (Kelly, 2011). The inclusion of participants was based on a criteria for inclusion. Potential participants of this research were identified based on meeting two criteria identified as: 1. they have a diagnosis of ASD (homogenous sampling) (Lund Research, 2012) and 2. they are currently using P.E.C.S. This criteria was developed so as to create validity and reliability. The diagnosis of ASD was essential in order to answer the research question and the use of P.E.C.S. was essential as the researcher did not have sufficient time to first teach children how to use P.E.C.S. The two SLT's based in the school identified children that met this criteria and distributed letters of information and letters of informed consent to the parents of these potential participants. The potential participants were then identified based on a self-selection process; 10 signed letters of informed consent were received by the researcher; thus, these were the participants. The purpose of purposive sampling is to identify people who hold a knowledge of the topic and access in-depth information from those willing to provide it (Cohen, Manion and Morrison, 2007).

As can be seen in recent studies within this area sample sizes appear small (O' Cionnaith, 2010; Domican, 2015; Voice4u, 2016 with some studies not including children with ASD in any design or developments of the App. Some studies utilise parents and professionals as proxies to represent the views of children with ASD. However, when designing research to incorporate people with disabilities extra consideration was required. Access to participants who are located in the one research site can impact on the sample size along with parent and professional motivation to engage in research. As

outlined in the limitations to methodologies section some stakeholders do not see the value in research and do not have the time to participate. Therefore, the researcher was dependent upon stakeholders to access participants and as a result made it more difficult to recruit participants (Warnell et al., 2015). The researcher obtained ten participants for this research and in comparison to similar international studies it is located at the higher end of the scale in relation to sample size. International studies focusing directly on mobile devices and communication Apps evidence sample sizes ranging from three participants (Ganz et al., 2013) to twelve participants (McEwen, 2014). The representativeness of this sample size to the population of children with ASD is difficult to assess due to the symptomology of children with ASD. However, from evidence gathered within the literature review the researcher secured a sample size that was representative on an international basis. Due to the ASD diagnosis received by participants it makes the case that these ten participants are in fact representative of their population (Warnell et al., 2015). The ratio of 1 in 100 also provides a case that to locate ten participants with ASD who use P.E.C.S., within the same site is unique; thus, increasing the case for representativeness.

Thus, the importance of the researchers skill set (social care professional) was evident here in gaining access to a research site that could facilitate the inclusion of potential participants. The sample size of this research is representative of the population and the difficulties in recruiting children with ASD within the one site evidences that a sample of ten is valid. The ratio of 1 in 100 people have a diagnosis of ASD assists in evidencing the representativeness of the sample. Nano Nagle School also provided the researcher with access to a multi-disciplinary team (children with ASD, parents, special needs assistants, classroom teachers and SLT's) for the purpose of engaging in the development of an App that was user led.

3.6 Ethical Research with People with a Disability

When conducting research within the social sciences it is imperative to obtain ethical approval prior to commencement. As outlined by the Economic and Social Research Council (ESRC) (2012), ethics is defined as 'the moral principles guiding

research, from inception to completion and publication of the results' (p.40). The term ethics refers to moral and professional standards that are upheld in a given situation (Gallagher, 2005). As defined by Resnick (2011), ethics are "norms of conduct that distinguish between acceptable and unacceptable behaviour" (p.1).

Gray (2009), identifies four primary areas of ethical principle. The four areas are: (1) avoid harm to participants, (2) ensure informed consent of participants, (3) respect the privacy of participants and (4) avoid the use of deception. In the planning of this research these four areas were addressed when seeking ethical approval. This research obtained ethical approval from the Institute of Technology Tralee's Research Ethics Committee. However, as this research involved young people with disabilities some extra considerations were required. When conducting research with people with disabilities the list of areas of consideration increases. As people with disabilities are identified as a vulnerable group, extra measures were required in order to ensure the welfare and protection of participants (Becker et al., 2004). This first consideration was the use of a methodology that incorporated the ethos of the principles of ethical research (National Disability Authority, 2002).

As stated by Coughlan and Brannick (2010), A.R. is 'grounded in principles of democracy, justice, freedom and participation' (pg. 132); however, the impact of the research on stakeholders must be considered. Hilsen (2006), makes the case that ethics in A.R. is based on three areas: human interdependency, cogeneration of knowledge and more balanced power relations. These three areas are reflective of the ethos of ethical research as outlined by Samuel and Zaiane (2014). There are six major principles outlined by Samuel and Zaiane (2014) that require adherence when considering ethical procedures include: 'non malfeasance, integrity, equality/justice, beneficence, autonomy and impossibility (pg. 3). As outlined above, there are variations in the number of guiding principles within ethical research; thus, the use of formal codes of ethics is important particularly when engaging with vulnerable populations of society.

As outlined by the National Disability Authority (NDA) (2002), the development of formal codes of ethics for disability research has not occurred yet. As of 2015, these formal codes are yet to be developed. However, due to the availability of literature in this area the researcher had the ability to form best practice guidelines for conducting research with children with ASD. The NDA (2002), developed guidelines for including

people with disabilities in research which formed the basis for the development of best practice guidelines. As a result of the collaboration of literature it is clear that the ethical considerations for research with people with disabilities over laps with that of codes of ethics on research participants from 'sociological and psychological associations' (NDA, 2002). As outlined in the Belmont Paper, there are three primary ethical principles that act as a guide when conducting research. These ethical principles include: respect for an individual's autonomy, a positive balance between the risks and the benefits of the research to the person and justice (i.e. fair treatment of participants). The NDA (2009), outlines five ethical considerations when conducting research with people with disabilities. These include: 'well-being and avoidance of harm, collaboration, consent, respect and equality and diversity' (National Disability Authority , 2009, p.3).

This research was primarily governed by the National Disability Authority (NDA) Ethical Guidelines for Disability research. The NDA views ethics and quality research as synonymous; thus, ethical research is in fact a quality assurance measure. Ethics is defined as "a set of standards by which a particular group or community decides to regulate its behaviour- to distinguish what is legitimate or acceptable in pursuit of their aims from what is not" (NDA, 2009, pg. 1). The NDA developed these ethical guidelines in par with international best practice guidelines and in consultation with people with disabilities. There are seven core values that underpin the ethical guidelines as set out by the NDA which underpin five key themes. The five key themes of ethics include: well-being and avoidance of harm, collaboration, consent, respect and equality and diversity (NDA, 2009).

The well-being and avoidance of harm is key for this research. Ward (1997) and Beresford (1997), identified additional ethical issues through researching with people with disabilities. Ward (1997), identifies effective safeguarding for participants as an essential element to consider. Ensuring the safety and well-being of participants is paramount, however, developing strategies to ensure this is key (Ward, 1997). The symptomology of ASD highlights these vulnerabilities; however, with strategies in place these can be overcome (See section 3.6).

Ward (1997), also advocates for the facilitation of appropriate participation. Gilbert (2004), identifies that determining the level of participation among people with disabilities is a challenge in itself. However, Gilbert (2004) also argues that the criteria

for determining participation can be adapted. For example, a person with a disability may not have the ability to engage in the data analysis process but has the ability to convey their thoughts on the process. Thus, the lay theory can underpin the formal theory (Baxter et al., 2001). The NDA (2002), focuses on a social model approach and emphasises the importance of empowerment of people with disabilities. The adaptation of the research process is key in order to facilitate appropriate participation and in turn create empowerment amongst people with disabilities (Aman and Handen, 2006). This participation involves collaboration with stakeholders along with respecting the autonomy of participants. Participants should be provided with respect and justice throughout the process. Providing participants with justice involves providing equality while respecting diversity. Applying justice to people with disabilities occurs on both legal and moral levels and is applicable directly to participants but also the community they are representing (Dalton and McVilly, 2004).

A study conducted in 2002 identified that there were low participation rates amongst children with disabilities in research; thus, a set of ethical guidelines was developed (Whyte, 2006). The ethical guidelines for children with disabilities in research were derived on foot of the overall underpinning core values. The five core values incorporated into these guidelines are: beneficence, non-maleficence, autonomy, fidelity and inclusivity (Whyte, 2006). The principles of these guidelines are reflective of these core values and are as follows:

- Committing to the well-being of participants and stakeholders of the research,
- Committing to ensure no harm is imposed on stakeholders,
- Committing to the rights of stakeholders,
- Being child-centred in the research approach, listening to children and treating them in a fair and just manner and
- Committing to inclusivity and facilitation of equal participation.

The development of this research was underpinned by the above core values and this is reflected throughout the research. The researcher had received ethical approval prior to engaging with stakeholders. The ethics process involved submitting an application form (See Appendix P) and the researcher was granted ethical approval and permission to proceed with field research upon satisfying minor corrections. Receiving

ethical approval was essential as the researcher was not only engaging with children but they were children with a disability; thus, making them more vulnerable. As participants were involved in the design and development of the App it was imperative that the researcher had regular contact with them and other stakeholders. Therefore, particular consideration needed to be given to the area of consent. As all potential participants were under the age of 18, parental consent was essential (Punch, 2006).

In conclusion, the issue of ethics when conducting research with people with disabilities is an issue that should not be taken lightly. As previously stated, there are extra steps required so as to include people with disabilities; however, the potential benefits of their involvement outweighs the extra planning. The additional considerations are undoubtedly time consuming; however, conducting research in the disability sector without the input of those directly affected is within itself unethical. The United Nations (2004), began a campaign with the focus of empowering people with disabilities to participate in development of strategies and policies impacting upon their lives which held the mission statement of; 'nothing about us, without us'. There are some ethical guidelines available for researchers; however, there is an absence of formal codes of ethics that would provide consistency within the sector. In order to ensure compliance to ethical guidelines and overcome barriers the researcher utilised three primary tools so as to uphold the five core values as previously outlined. The tools that were used in this research include: an information meeting, letters of information and letters of informed consent.

3.6.1 Information meetings

Information meetings were used for the purpose of providing stakeholders with an overview of the research and providing them with the aims and objectives (See Appendix Q). This also gave stakeholders the opportunity to raise any concerns they may have had. One of the main aims of this sessions was to create transparency for stakeholders. The use of the information session allowed stakeholders to make an informed decision about participation in the research. The researcher also had the opportunity to manage expectations as there was concern that due to a lack of knowledge around this area that parents and professionals may expect greater

outcomes that intended. This session was effective in brining stakeholders together to create a sense of partnership for the research going forward.

3.6.2 Letters of information

Letters of information were distributed to all potential participants by SLT on behalf of the researcher (See Appendix R). This letter outlined the background to the study, aims and objectives and indicated the roles that would be required from participants. The letter of information also included the researchers contact information if parents needed clarification in any issues. The letter of information was developed in line with ethical guidelines and was accompanied by a letter of informed consent.

3.6.3 Letters of informed consent

The principle of informed consent along with the capacity of a person with a disability to provide informed consent is of primary concern when conducting research with people with disabilities. Informed consent can be achieved by providing stakeholders and participants with information that is transparent and presented to them in an accessible format; be it written, verbal or visual. In order to abide by ethical guidelines it is essential to obtain informed consent from all stakeholders and participants. This is particularly important when engaging with children as it is a legal requirement to gain informed consent from the parents when engaging in research with anyone under the age of 18 (Whyte, 2016). As stated by Coons and Watson (2013), informed consent is essentially an individual's comprehension of the information they are provided with. In the area of research with people with disabilities, informed consent holds several components. These components include:

- Ability to understand and grasp the information provided,
- Be provided with the opportunity to discuss the information,
- Be free from coercion in their consideration as to whether or not they want to participate in the research,
- Have the capacity to consent.

(Coons and Watson, 2013 and NDA, 2002)

In order to abide by ethical considerations, the researcher developed a letter of informed consent for parents of potential participants. Signed letters of consent provided the researcher with access to participants. The researcher received 10 signed letters of informed consent. The letter of informed consent was developed in line with ethical guidelines (See Appendix S). It was made clear to participants that they could remove themselves from the research at any time without consequence if they so wished. The use of iPads was also clarified in this letter. In order to ensure that participants were not enticed by the use of an iPad it was transparent that for the purpose of the research the researcher owned the iPads and they would be donated directly to Nano Nagle School Listowel upon completion of the data collection phase. The letters of information provided clarity and transparency to participants.

3.6.4 Software development ethical guidelines

The decision to develop an App also brought about its own ethical considerations. The ACM/IEEE-CS has collaborated to develop a 'code of Ethics and Professional Conduct' for software developers which the researcher adhered to in the development of the App. This code of ethics focuses on eight principles that guide the developers in their engagement with end users. The eight principles include:

- acting in the best interests of the public, their client and employer,
- ensuring that their products meet the highest professional standards available,
- maintaining integrity and independence in professional judgement,
- managers and leaders promote an ethical approach to the management and maintenance of software development,
- advancement of the integrity and reputation of the profession,
- supportive of their colleagues and
- participation in continuous professional development (CPD).

(Association for Computing Machinery, 2015)

These eight principles are reflective of the previous themes highlighted in the area of social science ethical guidelines; therefore, there is a common thread amongst ethics in social science and computer science. The collaboration of these areas brings about a discipline 'health informatics' (Epstein, 2013). The concept of health informatics is the

merging of three sciences; health care, information science and computer science (UKCHIP, 2015). Samuel and Zaiane (2014), clearly illustrate the components of health informatics and the ethics that are necessary prior to engaging with any research within this area.

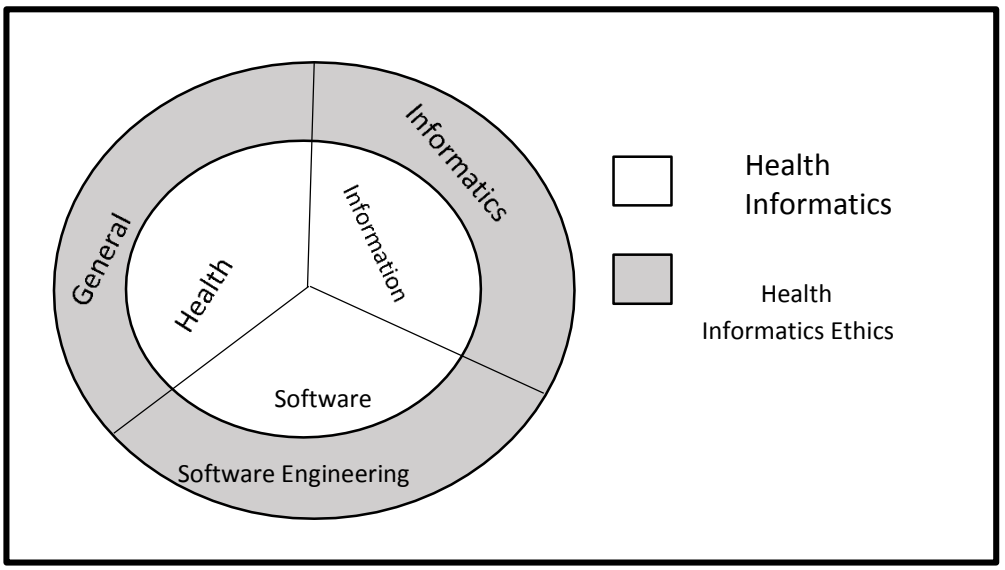


Figure 2Components of Ethics for Healthcare Informatics

General ethics comprises of norms and values of social interaction that are underpinned by the six major principles outlined earlier in the chapter. Informatics ethics is specific to informatics and comprises of seven key concepts: 'privacy, openness, security, access, legitimate infringement, least intrusive alternatives, and accountability' (Samuel and Zaiane, 2014, pg. 3). Software engineering ethics involves consideration of end-users and societal impact of their software (Samuel and Zaiane, 2014).

The researcher ensured compliance with ethics by addressing each area in the Institute of Technology Research Ethics Committee ethics application form. The use of methodological tools assisted in achieving this aim. As a result of addressing each area the researcher ensured that the research would remain professional, valid and reliable.

Within health informatics there are governing bodies that promote the use of ethical and professional codes of practice when engaging in App development. Health informatics is defined as 'the knowledge, skills and tools which enable information to be collected, managed, used and shared safely to support the delivery of healthcare and promote health' (UK Council for Health Informatics Professionals, 2015, pg. 1). There are three key governing bodies available to Irish health informatics professionals; Healthcare

Informatics Society of Ireland, iChip and the UK Council for Health Informatics Professionals (UKCHIP).The Healthcare Informatics Society of Ireland (HISI) focuses on bridging the gap between healthcare professionals interested in computer sciences and computing professionals interested in healthcare (HISI, 2015). HISI is a national body that focuses on the development of knowledge and research in the area of health informatics and collaboration with similar international bodies (HISI, 2015). The researcher is a student member of HISI; thus, has pledged to abide by their codes of ethics and professionalism. HISI is also affiliated to iChip and promote registration to facilitate continued professional development (CPD).

iCHIP is the Irish version of UKCHIP and is a forum for professional registration. iCHIP brings with it its own codes of ethics and professionalism and holds a particular focus on CPD. The researcher has completed the process of preliminary registration with iCHIP as full registration has not been rolled out as of yet (HISI, 2015). As a result of this the researcher has engaged with UKCHIP.

The UK Council for Health Informatics Professions (UKCHIP) is a regulatory and registration body for health and social care informatics that outlines standards for its members to abide by when engaging in the health informatics area (UKCHIP, 2015). The researcher is now a student member of this body; thus, is bound to their ethical guidelines. UKCHIP illustrate their core values and standards in the form of a 'benefit tree' which details their standards, the beneficiaries and the outcomes as a result of upholding these standards (UKCHIP, 2015). At the base of the tree is professionalism which symbolises that any standards are rooted in professionalism and this is the guiding force for effective implementation of standards (UKCHIP, 2015). The trunk of the tree symbolises the UKCHHIP core standards from which value is developed. The branches represent the types of beneficiaries and the leaves symbolise the expected outcomes and qualities resulting from a profession that is regulated (UKCHIP, 2015).

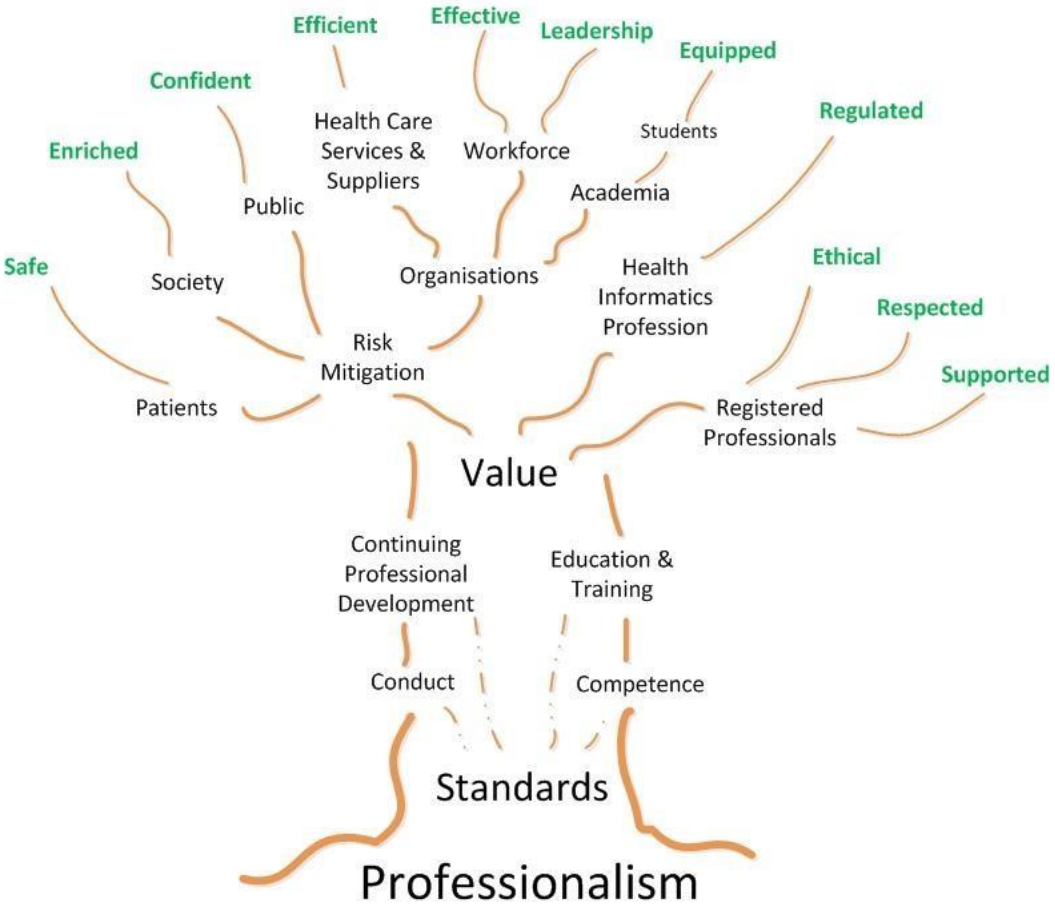


Figure 3UK CHIP Professional and Ethical Standards (UKCHIP, 2015

The researcher utilised this diagram throughout the research process; particularly in the data collection phase. It was important for the development of the App to abide by ethical guidelines so as to protect the end-users against potentially harming events.

3.7 Universal Usability

The concept of universal usability was derived by Shneiderman in 2000. Universal usability focuses on three core area's; which include: 'user diversity, technology diversity and bridging the gap between what users know and what they need to know' (Lazar, 2007, pg.1) .User diversity is defined as 'novice and expert users, younger and older users, users with perceptual, cognitive, and motor impairments, users with learning disabilities, low-income users and illiterate users' (Lazar, 2007, pg.1). Technology diversity is defined as 'desktop computers, laptop computers, portable devices and PDA's, mobile phones, and various screen sizes and connection speeds' (Lazar, 2007,

pg.1). There are currently gaps in the area of using technology with minority groups within society (Lazar, 2007).

There is a gap between the knowledge individuals have about technology and the extra information they require so as to make technology accessible to them (Lazar and Jaeger, 2011). Some methods that have been developed in order to attempt to fill the gaps include: help menus, tutorials, and natural-language assistance systems (Lazar, 2007). The development of such tools aim to increase accessibility for end-users (Frazer, 2016). The term 'accessibility' is defined as 'the possibility of a website to be used by people with the widest range of abilities, including people with disabilities' (Stephanidis and Antona, 2014, pg. 3). As a result of the development of accessibility guidelines software developers are now developing with end-users in mind and are being encouraged to adopt more of a user-centred design approach to their projects. However, the participation of end-users in the design and development phase of an App is key to a truly effective user-centred design (Kujala, 2003).

3.8 User-centred Design

The decision to undertake the development of an App for children with ASD was one that was not taken lightly. Research has shown that the development of these types of Apps has taken on two approaches: 1. Software developers create them independently and 2. Parents of children with ASD develop them in partnership with software developers (O' Cionnaith, 2010; Domican, 2011; Voice4u, 2016). When developing for children with ASD it is imperative that the developer has knowledge and experience in working with children with ASD (McEwen, 2014). We cannot expect a professional to develop an App for a population that they are unfamiliar with. The development of Apps by parents is effective; however, it is effective for that one child. When designing for a population it is important to consider as many aspects as is possible so as to meet their needs. Prior to engaging in the development process the researcher conducted usability analysis (See Appendix T) on communication Apps currently available for download. The results of this showed that the functionality available within the Apps vary; thus, it is difficult to meet the needs of every end-user through the utilisation of just one communication App. Therefore, the ethos of developing *with* as opposed to *for* children with ASD was justified so as to create an App that meets the needs of end users. Thus,

the utilisation of a methodology that incorporated the voice of the participant was required. As a result of this, User-Centred Design was implemented for the development of the App.

User-Centred Design (UCD) is also known as 'human-centred design' (Web Accessibility Initiative, 2004) and it focuses on the user throughout the design process (Abras et al.,2004). Therefore, user-centred design incorporates the user in the planning, design and development of a product (Abras et al., 2004). As stated by Norman (2002), User- centred design should ensure that; the user can independently figure out what to do and is aware of what is going on. This process generates continuous feedback from the user (Lubas et al., 2014). User-centred design has the potential to be used as a multi-disciplinary approach in the development of communication apps for children with ASD (Lubas et al., 2014). The use of professionals (i.e. Speech and Language Therapists, Applied Behaviour Analysis Consultants, Teachers), parents and children create this multi-disciplinary approach (Lubas et al., 2014). User-centred design focuses on designing for the user (Sanders, 2002). Lubas et al. (2014), highlights the benefits of user-centred design when developing apps for children with ASD. However, in order to maximise the potential of user- centred design and to create a framework for designing *with* as opposed to *for* children with ASD, there are adaptations that need to be made (Sanders, 2002). Abbott et al. (2011), advocates for the use of user-centred design along with experimental design to incorporate and meet the needs of children with autism when developing software. Experimental design focuses on internal validity i.e. cause and effect (Trochim, 2006). Newell and Gregor (2015), also support the ideology of a combination of user centred design and experimental design. The incorporation of a multi-disciplinary approach is another element that could be of benefit to enhance the process of user-centred design (Lubas et al., 2014). Professional and parental opinions have the potential to enhance the identification of the needs of the children within the design process (Lubas et al., 2014). The involvement of children in the design and development phases is essential for future developments of these types of technologies.

The framework that was utilised for this research is that of the UPA Designing for the user experience (See Appendix U). Treder (2012), developed this framework during his practice within a large company so as to encourage his colleagues to engage in user-

centred design. Treder (2012), noticed after a short time within the company that even though they offered a UCD service; the employee's weren't engaging in it. Treder (2012), attributed this to the fact that there were too many steps and requirements in traditional UCD processes; not only making it time consuming but also expensive. As a result of this, he decided to create an adapted theoretical approach to UCD that would fit the needs of the company and that allowed optimization of the company's main service. The framework developed by Treder (2012) acquires approximately 20% of a theoretical framework for UCD; however, it is a simple, efficient and effective design framework. Treder (2012), states that 'a simplified process is better than a robust unactionable theory' (pg. 1).

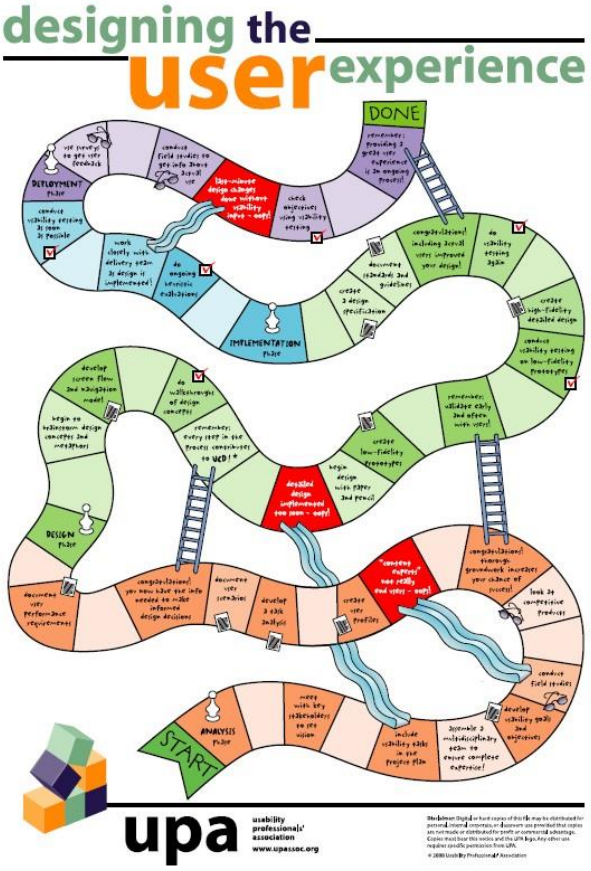


Figure 4UPA Designing for the user experience

This framework is derived of four phases (Analysis, Design, Implementation and Deployment) with several steps in each phase. The framework is presented in a 'snakes and ladders' type graphic which highlights the key component of UCD; it is an iterative process. This framework is discussed in greater detail in chapter 4 with respect to the implementation of the App along with creating a multi-disciplinary framework.

3.9 Usability Testing (U.T.) with Children with Autism Spectrum Disorder (ASD)

Usability testing (U.T.) is a key feature of user-centred design and is an essential iterative process for the development of any product so as to meet the needs of the user (Lowdermilk, 2013). Usability testing is 'a systematic way of observing actual or potential users of a product as they work with it under controlled conditions' (Dumas and Loring,

2008, pg.3). U.T. focuses on moving from low-fidelity (paper prototyping) to a high-fidelity prototype (the actual product or a version of the product) (Dumas and Loring, 2008). Engaging in U.T. with children with ASD upholds the same importance but brings about more challenges and barriers than the average U.T. session (Kamaruzaman and Azahari, 2014). The characteristics and needs of the participants must be at the forefront from the onset of planning U.T. (Kamaruzaman and Azahari, 2014). This section begins by outlining the concept and components of U.T. and then discusses the process and the adaptations required in order to successfully engage in a U.T. session with children with ASD.

Usability testing is defined as 'carrying out experiments to find out specific information about a design' (Horn, 1996, p.35). U.T. focuses on determining how the product is understood, how easy it is to learn and operate and how attractive it is to the user (Zaman and Bhuiyan, 2014). The aim of a U.T. session is to 'measure the effectiveness of a feature or set of features within your application' (Lowdermilk, 2013, pg.96). U.T. is a scientific process that quantifies your observations and assumptions (Zaman and Bhuiyan, 2014). As stated by (Lowdermilk, 2013), U.T. sessions are more productive and accurate when they are planned, organised and measurable. This can be completed by ensuring that: (a) you have the right participants, (b) you have a prepare script and (c) you develop a set of guidelines. As a result of engaging in these three steps practitioners empower their session to collect data that is consistent and viable (Lowdermilk, 2013). Sanders and Curran (1994), states that there are three categories that need to be explored in any U.T. session; these include: understand-ability, learnability and operability. U.T. should occur at every stage of software development and design (Zaman and Bhuiyan, 2014) and should be based on the results of data collected i.e. questionnaires, surveys and observations (National Institute of Standards and Technology, 2015). There are four types of tests used for usability testing in research and software development: exploratory, assessment, validation and comparison (Zaman and Bhuiyan, 2014).

Table 3 Types of usability testing methods

Type	Description
Exploratory	This form of U.T. is also known as formative usability testing. This type of testing is used to collect qualitative data in relation to the user interface concepts and design (National Institute of Standards and Technology, 2014). This is a valuable process in relation to collecting data on addressing the needs of the participants. This type of testing should occur early in the design life-cycle (University of Washington, 2014).
Assessment	This U.T. method is the one that is the most common method used. This occurs early to midway through the design of the product (University of Washington, 2014). The aim of this method is to investigate the effectiveness of the implementation (University of Washington, 2014).
Validation	This usually occurs late in the development life-cycle and when the product is close to release (University of Washington, 2014). This type of usability testing aims to verify that the issues identified earlier have effectively been addressed (Rubin and Chisnell, 2008). As outlined by Rubin and Chisnell (2008), validation usability testing provides an evaluation of how the product compares to standards of performance of other similar products and the standards as outlined in the usability objectives. This is a vital stage in relation to the development of standards for future products.
Comparison	This can be used at any point throughout the development life-cycle (Rubin and Chisnell, 2008). It can be used in conjunction with any of the first three tests and its main aim is to identify which design is easier to use (University of Washington, 2014).

This research adopted aspects of both Exploratory and Assessment U.T. so as to collect data that is reflective of the usability goals. Users were asked their opinion on the user interface and data was also collected in relation to their engagement with the App (e.g. does the App provide them with the scope they need to construct their desired sentence). A mixed-method approach was used in order to collect data that is reflective of the needs of the users; thus, informing the development of later versions of the App. Time was also a consideration as a bank of data needed to be collected (so as to inform the development of the App) prior to the end of the school year.

Once the researcher had decided on the most suitable type of usability test to use, the next step was to identify a moderating technique. A moderating technique is 'critical to gaining insights and understanding about your users needs' (Romano Bergstrom, 2013, pg.1). The chosen moderating technique should be underpinned by the usability goals of the research (Cao, 2015) (see Appendix V). Cao (2105), states that usability goals are essential to 'know why before how' (pg.1). Usability goals aid practitioners and researchers in focusing on what type of data is most appropriate and relevant to the life-stage of the product being tested (Cao,

2015). Usability goals are therefore an important aspect for the development of the type of moderating technique that were used for the U.T. session. Romano Bergstrom (2013), identifies four moderating techniques used in order to conduct effective usability studies; they are: Concurrent Think Aloud (CTA), retrospective Think Aloud (RTA), Concurrent Probing (CP) and Retrospective Probing (RP) (U.S. Department of Health and Human Services, 2014,).

Table 4 Moderating Techniques in Usability Testing

Type	Description
Concurrent Think Aloud (CTA)	A process where participants are encouraged to engage in a running stream of consciousness as they work on a particular task within the App. The only engagement the researcher makes with the participant is to use prompts such as "keep talking". However, it is important to note that participants may take longer to complete a task as a result of engaging in CTA.
Retrospective Think Aloud (RTA)	Occurs once the session is complete. The researcher asks the participants to retrace their steps of the task they have just completed. This approach eliminates the limitations of CTA.
Concurrent Probing (CP)	Involves researcher-participant engagement. When the participant makes an observation/comment aloud, the researcher uses probing questions to find out more information. This approach effects the natural thought process and progression within the task.
Retrospective Probing (RP)	Occurs when the session is complete. The researcher listens to participants comments and asks follow-up questions. This approach is often used in conjunction with other methods.

The evaluation of the most suitable moderating method to be used for the study was crucial for the success of the U.T. session. This was particularly relevant when working with children with ASD as again adaptations were required. This research utilised aspects of both concurrent think aloud and retrospective probing as the moderating techniques. These techniques were adapted to meet the needs of the users. For, example, for participants who were non-verbal the researcher utilised observations to record the participants engagement with the App. The depth of responses from participants who were verbal was also limited and the feedback they gave was broad; nonetheless, it was valid. The teacher acted as the facilitator for the U.T. session and this in turn became a strength as they were familiar with the participant and had knowledge on how and when to probe questioning to gain feedback from the participant. However, other elements

also required consideration when planning the U.T. session. As outlined by Romano Bergstrom (2013), there are four basic questions for U.T. that a research should ask themselves. These include:

- Can the participants work through the tasks independently?
- Will the researcher need 'time on task' and 'accuracy' data?
- Are the tasks multi-layered and require concentration on the part of the participant?
- Will the researcher be conducting eye tracking?

These questions were particularly important when conducting U.T. with children with ASD due to their diverse and unique characteristics.

As with any methodologies there are both pro's and con's to using any of the outlined frameworks. However, a consistent aspect of U.T. is the guidelines for best practice. These guidelines for best practice are parallel with the ethical guidelines being adhered to for this research. The University of Illinois (2013), provides a brief list of best practice guidelines for engaging in U.T. Some of the guidelines provided include:

- Keeping the test short- people lose concentration and get tired; therefore, the feedback you receive will become less informative. The recommended length of time for a U.T. session is a maximum of 20 minutes.
- Allow the user to do the work and avoid temptation to interfere or help. Observe the user and figure out how to assist the user more through the software.
- Encourage the user to narrate their thought process when engaging with the software.
- Remove distractions as children with ASD are more easily distracted by sensory stimulus (e.g. shadows, noises) or unfamiliar objects (IBM, 2014).
- Take notes but ensure confidentiality when doing so.
- Treat participants with respect and dignity and make them feel as comfortable as possible.

- Avoid the use of questionnaires and use interviews instead as a form of briefing and de-briefing (IBM, 2014).

Romano Bergstrom (2013), reinforces the importance of these topics for best practice when engaging in U.T. and highlights the importance of reassuring users that it is the software that is being tested and not them. These best practice guidelines hold the ethos of the safety and welfare of participants and are therefore compliant to the ethical guidelines underpinning this research. U.T. is an iterative process and should be conducted at intermittent times throughout the design process (Foraker Labs of Boulder, 2014).

In conclusion, U.T. was an essential method for capturing data that assisted in developing software and applications that meet the needs of the user. As outlined in this section, there are several methods to choose from in U.T. and each method brings with it both pros and cons. In order to conduct U.T. with children with ASD it is important to consider adaption of these traditional methods to provide participants with a more meaningful role in the process. When conducting U.T. with children with ASD it is essential to:

- Follow best practice guidelines and make the process as comfortable as possible for participants,
- Adapt traditional usability testing methods so as to ensure that the research is continuing to uphold a user-centred design,
- Ensure that the session is planned in order to meet the diverse needs of the children with ASD.
- Finally, remember to observe behaviours and communicate with participants to extract richer data.

3.10 Distribution of methodological tools

In light of the discussions presented throughout this chapter, the distribution of methodological tools was of key importance to abide by A.R. principles along with engaging in the UCD process. The diagram overleaf (figure 5) provides an illustration of

the chronological order of the distribution of each tool. The black arrows indicate chronological order while the yellow arrows indicate how each tool influenced the development of the next. These methodological tools were utilised so as to collect data that addressed the research questions presented. The results of these tools are detailed in the above sequence in Chapter 5.

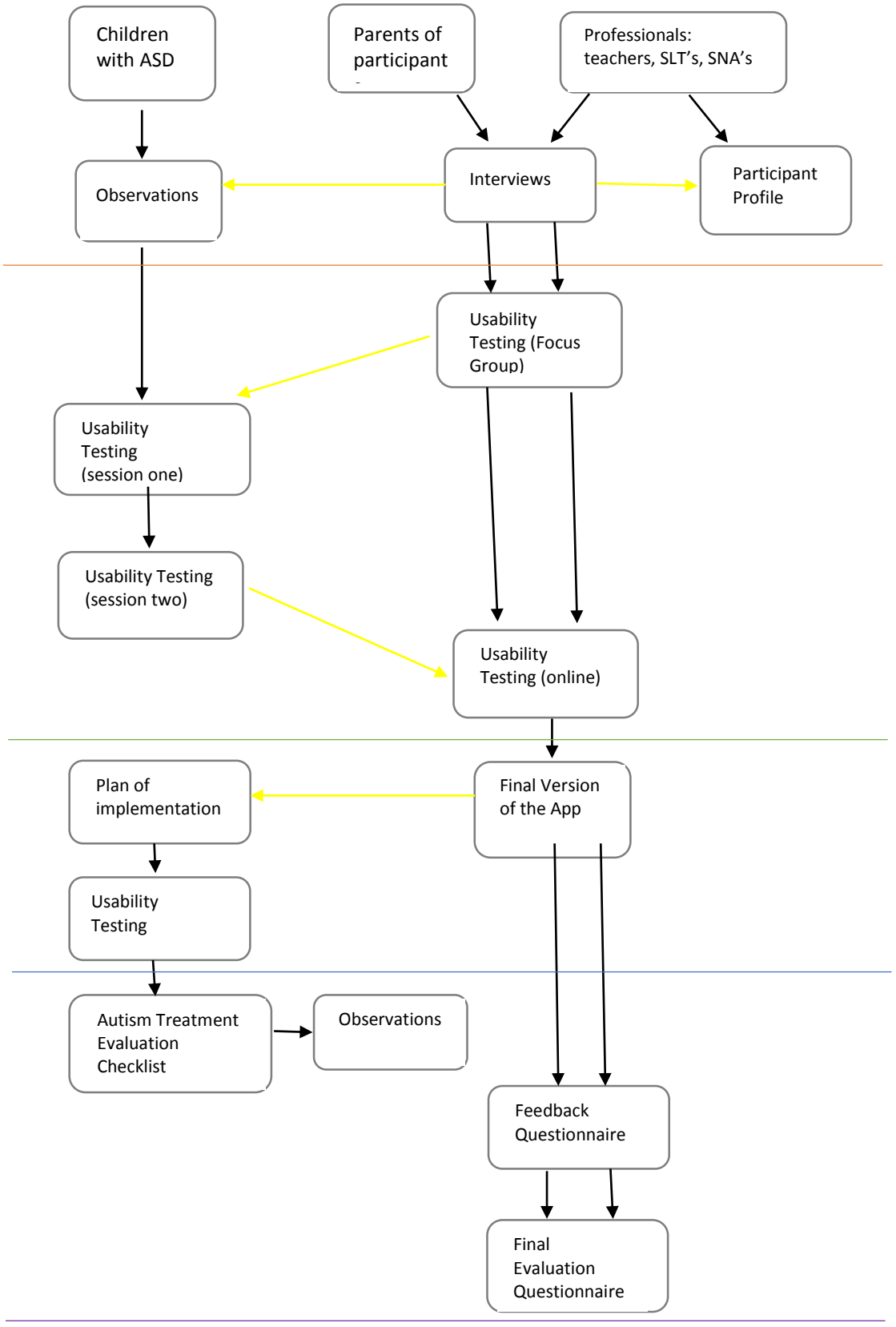


Figure 5 Distribution of methodological tools

3.11 Chapter Summary

In conclusion, Chapter 3 provides an overview of the methodologies that were utilised so as to develop an App *with* children with ASD and their stakeholders as opposed to *for* them. This research was initially guided primarily through the socialsciences perspective; however, in order for the researcher to develop the App it was imperative to incorporate a computer science methodology. The principles of the UCD framework was in parallel with the ethos of action research; thus, its incorporation was relevant and effective for the research. The sample size for this research was proven valid through the use of literature. In fact, it is rare to locate such a large sample in the one site due to the heterogeneous nature of ASD. Ethics was of paramount concern during this research due to the vulnerability of the population and also their age as they were all under 18 and classified by law as children. Even though there are no formal codes of ethics for disability research and particularly research with children with disabilities, the National Disability Authority were a guiding force for this research with their development of guidelines for disability research. The use of ethics was not only of concern within the social sciences, but also within the area of computer sciences. The researcher also had to consider and implement these ethical guidelines so as to ensure the development of an App that was compliant to standards. As a result of this research being interdisciplinary, the area of health and social care informatics was discussed. The three ethical components of applicability in the area of health and social care informatics were: general ethics; informatics ethics and software engineering ethics. The combination of these disciplines has allowed for the development of an App that is multi-disciplinary and end user focused.

Chapter 4: Implementation

4.0 Design and Implementation of the App: Introduction

Chapter 4 aims to discuss the process which was undertaken to develop a communication App with children with ASD and their stakeholders while utilising a multi-disciplinary approach. The App was developed and tested through formative and summative testing. Summative testing is based on evaluations of a product (User Experience Professionals Association, 2012) and is discussed in chapter 5 along with the findings of the research. Formative testing is defined as 'a methodology used to obtain qualitative reactions to user interface concepts and designs' (National Institute of Standards and Technology, 2016, pg.3). The purpose of formative testing is to iteratively evaluate a product during its development so as to create feedback and learning (Theofanos and Quesenbery, 2005; Northern Illinois University, 2016). The layout of chapter 4 mirrors that of the process of formative testing through a discussion of the methods and tools utilised for the development of an App that upholds a UCD process. As stated by the Northern Illinois University (2016), a primary focus of formative testing is to identify areas that require improvement and provide a solution or modification to meet the needs of the end-users. This type of testing was particularly evident when engaging in the User-Centred Design process. As previously outlined in chapter 3, the researcher utilised the UPA Designing for the User Experience framework when engaging in the UCD process. However, this process required adaptation in order to meet the needs of the end-users. Section 4.1 begins by discussing this process along with the adaptations that were required to create a multi-disciplinary framework for designing *with* the user. This framework identifies the importance of formative testing in all four phases of development. This formative testing is also linked to the standards of App development.

Standards are explored in section 4.2 where the researcher discusses the sets of standards that were referred to during the UCD process. The standards aim to provide the end-users with a product that is effective and efficient in its purpose. In order to ensure cross platform support the researcher used Html, CSS and JavaScript as the programming languages for the App. The researcher began developing a web App using

these languages. However, prior to undertaking this task the researcher was required to undertake continued professional development (CPD).

Section 4.3 of this chapter discusses how the researcher undertook the task of up-skilling in order to learn the programming languages required to develop the App with the children and their stakeholders. This was a steep learning curve to undergo as the researcher is a social care professional who had no knowledge of programming prior to the research. Upon completion of CPD the researcher had the skills to begin developing the App.

The development of the web App is discussed in section 4.4 where the researcher provides a description of web Apps along with a justification for its use. The researcher was provided with flexibility through the use of web Apps as the operating system being used to test the App was not clarified until later in the research process. The researcher had developed several iterations of the App prior to deciding on the operating system being used.

Section 4.5 of this dissertation provides an extensive overview of the five versions of the App and justifies the features used and eliminated in each version. Formative testing is particularly evident in this process through the use of observations and checklists (Northern Illinois University, 2016) for usability testing. This section highlights the iterative process that was engaged in so as to ensure that the App met the needs of the end-users. Feedback was received from parents, professionals and children with ASD during these iterations and literature was also incorporated into the rationale for use of features. The researcher conducted usability testing in order to obtain feedback from the children; however, this was a process that also required adaptation and consideration.

In light of this, section 4.6 gives an account of the considerations that were required prior to conducting usability testing with children with ASD. The symptomology of ASD was again of importance in this section along with the implementation of ethical guidelines. The researcher held a primary focus on ensuring the care and welfare of participants was protected at all times and undue stress was not imposed upon them at any stage as a result of testing the App. The results of the usability testing sessions

informed the development of the features that were incorporated into the final version of the App. This is again an example of formative testing.

Section 4.7 focuses on six key features of the App and provides an extensive account as to how and why each was implemented. The six features include: sourcing images, screen layout, categories, voice, camera feature and priority to iPad. Each of these features were informed by either the stakeholders or participants of the research (children with ASD). Upon identification of the required features, the researcher was then required to port the web App to a mobile App that could be deployed on the iPads for use by the children.

The researcher utilised a tool called PhoneGap for the purpose of producing a mobile App for deployment and testing. Section 4.8 provides an extensive overview of this framework along with the features and limitations it provides. The researcher has also provided an evaluation of the framework from the perspective of a social care professional up-skilling to become a multi-disciplinary professional. This section is primarily aimed at heath and social care professionals who have an interest in the area with the possibility of entering the sector of health and social care informatics. Thus, the researcher has structured this section with these professionals in mind. Once the App was produced the researcher began the implementation phase.

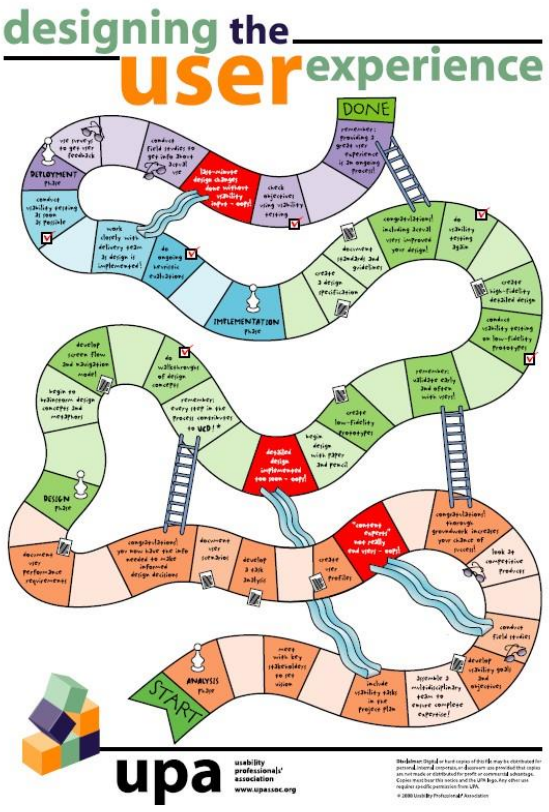
Section 4.9 discusses this implementation phase and provides an account of the tasks required to ensure successful implementation. The researcher provided written and hands-on support to stakeholders during the implementation phase of the research. Stakeholders were provided with a training session prior to implementing with the children and were also given written and visual supports for themselves and the children for the facilitation of implementation in the absence of the researcher.

As with any research project there are difficulties that were encountered through different stages of the project. In section 4.10 the researcher discusses the difficulties that were encountered during this project while also providing a solution to them. The difficulties encountered can be categorised into two: practical and personal. Some of the practical difficulties included receiving buy-in from stakeholders and managing expectations of stakeholders. Whereas some of the personal difficulties included:

equipment and the journey to transitioning from a Social Care Professional to a multi-disciplinary professional. When the operating system was decided upon, the researcher required a Mac computer so as to develop the App specifically for iPad; however, the researcher did not own one personally. These obstacles are discussed in greater detail in the sections below; beginning with the adaptation of the UCD framework to facilitate multi-disciplinary collaboration.

4.1 Adapted UCD framework

Due to the multi-disciplinary approach to this research it was very important for the researcher to utilise a framework for development that was accessible to both disciplines. Because UCD holds a very similar ethos to action research it was decided that a UCD framework would be utilised. This framework was chosen due to its clarity, ease of use and applicability to the research. In order to merge the two disciplines effectively it was essential for the researcher to adapt the UCD 'Designing the User Experience' framework so as to create a framework for designing *with* children with ASD and their stakeholders as opposed to *for* them (See Appendix W). This development process incorporated the use of formative and summative testing. The formative testing took place in all four phases (analysis, design, implementation and deployment) whereas, the summative testing took place in the final phase (deployment). Each phase is discussed independently along with the adaptations that were made so as to create a multi-disciplinary framework. The researcher added twenty-one steps in total across the existing framework to facilitate



the collaboration between computer science practice and social science practice. However, within these twenty-one steps there were three key areas reflected throughout that were addressed: ethics, tools used to gather data and stakeholder participation. The remainder of this section discusses the steps that were required to adapt this framework so as to incorporate children with ASD and stakeholders in the design and development of an evidenced based communication App.

4.1.1 Analysis Phase

As shown in Figure 6 below, the analysis phase focuses on the completion of tasks such as, meeting stakeholders, creating a focus for the project, assessing current products available in the area and developing profiles of end-users. This phase required the most adaptation for the purpose of including social science theory and practice with the aim of creating a multidisciplinary framework. This in itself reiterates the importance of stakeholder and end-user involvement from the outset of a project. The remainder of this section discusses the steps that were incorporated and provide a rationale for each.

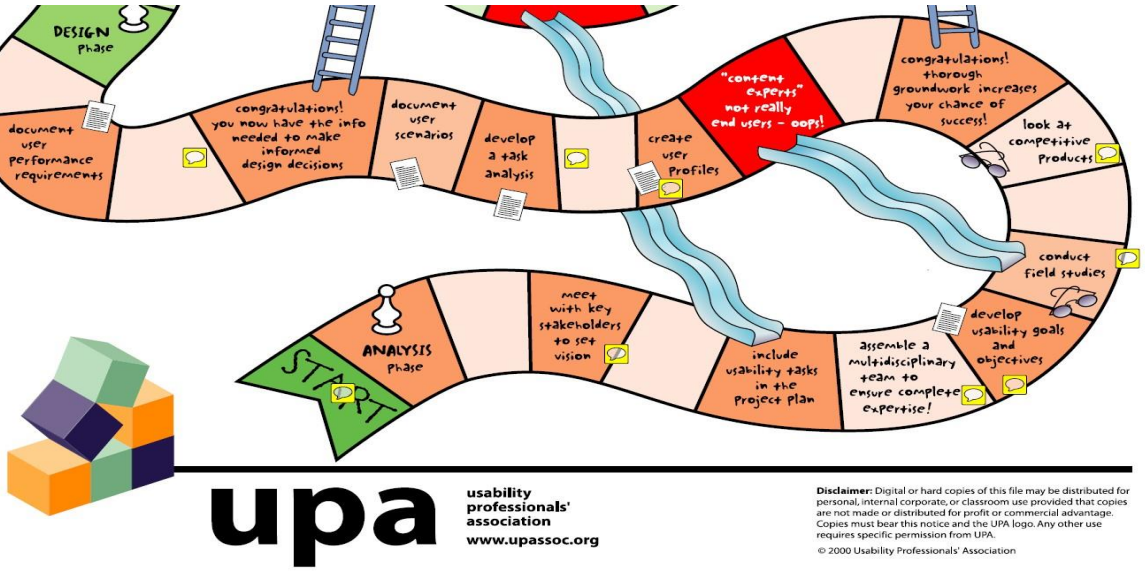


Figure 6UPA Designing the User Experience- Analysis Phase with adaptations

As seen in Figure 6 above, nine adaptation steps (See Appendix W) were required within this phase (the steps with the comment symbols indicate a step that was added). The nine steps were incorporated into seven themes where the focus was to begin

stakeholder involvement at the earliest possible stage. These nine steps are addressed under the following seven points:

1. Prior to commencing this phase it was essential for the researcher to obtain ethical approval. When working with vulnerable groups in society their safety and welfare is of upmost importance; ethical approval provides the safeguards for this. In order to comply with ethics the researcher made initial contact with parents of potential participants by liaising with the school principal and the Speech and Language Therapists (SLT). The SLT team identified potential participants based on the criteria outlined by the researcher and the tools utilised to facilitate contact were letters of information and letters of informed consent. The use of these tools allowed parents to make an informed decision about the intervention based on its own merits and without the influence of the researcher. The identity of potential participants and their parents was also kept confidential until they had signed the informed consent letters. The researcher was the only person in the research team who had access to participant and parent identity and this occurred when parents attended an information session.
2. When meeting with stakeholders providing them with an information session was of key importance. The four aims of the information session were:
    a) Outline the aims and objectives of the research,
    b) Manage expectations of outcomes,
    c) Clarify the roles of stakeholders,
    d) Buy-in! This is key for successful design participation and implementation. If stakeholders do not see the benefit to an intervention or see their value evidenced within the research they are less likely to become invested and provide their expertise (Campigotto et al., 2013).
3. The development of a multi-disciplinary team is essential in order to ensure that different perspectives are sought for the design and development of the App. A multi-disciplinary team should exist twofold; within the research team and within the research site. The research team for this project consisted of members from the social sciences along with computer sciences. This ensured that the ethos of both disciplines was present throughout the research. The multi- disciplinary team within the research site incorporated stakeholders from the disciplines of

education and Speech and Language. Parents of participants are a discipline in their own right and play a crucial role in the lives of their children (Chien et al., 2015). The parents of participants were incorporated into the design process and consulted with at as many stages as possible. The children participating in this research were at the forefront of every decision. Children with ASD were involved at the earliest possible stage; however, this was dependent upon each individual child. For example, introducing a low-fidelity paper prototype to a child with ASD may not be appropriate as the concept may be too abstract for them and they may not be able to provide effective feedback. The lack of engagement with the low fidelity prototype also runs the risk of causing frustration for the child as they are unsure about what is expected of them. A characteristic of ASD is impairments in imaginative play; therefore, it may be hard for the child to visualise the behaviours of the prototype without a working high fidelity prototype.

4. Conducting interviews with parents, teachers and SLT was a fundamental step in establishing user requirements and potential needs of users.
5. Conducting observations of the children was important for several reasons:
   a) They allowed the researcher to build a profile of the typical behaviours of each individual,
   b) The researcher had the opportunity to record the current use of the metaphor (P.E.C.S.) and the children's interaction with it and
   c) It provided the opportunity to collect user requirements that would feed into early versions of the prototypes. This was one of the earlier methods of formative testing that were used to create an App that would meet the needs of end-users.
6. User profiles are a vital component for the collection of user requirements and validation of tracking of behaviours in the data collection phase. The issue of ethics was evident here as the researcher was provided with personal information on children; thus, the researcher was the only person to view these.
7. Continued observation of participants on a fortnightly basis was important for the researcher to get familiar with the participants typical behaviours. In order for the researcher to conduct effective data collection it was essential that the

research would be able to identify how participants currently communicated with peers, staff and their parents; thus, it was decided to conduct observations. Observations were conducted with participants on an informal and formal basis. The informal observations commenced in April 2015 and ceased in June 2015. The purpose of these observations was to assist the researcher in getting to know each individual participant's profile. The areas that the researcher focused on during observations were: communication, social interaction, behaviour that challenged, independence and attention span. These areas were reflective of the categories being assessed in the formal observations (utilising The Autism Treatment Evaluation Checklist). It was important for the researcher to develop a greater knowledge around the profile of each child as this assisted in eliminating any errors that may occur when recording formal observations (Wall, 2011). Formal observations were conducted in phase 4 (deployment) of the intervention.

Once the researcher had completed all of the steps successfully, the design phase could commence which is indicted in figure 7.

4.1.2 Design Phase

As can be seen in Figure 7 overleaf, the design phase focused on the incorporation of user requirements first into low fidelity prototypes and then into high fidelity prototypes. There was an emphasis on user engagement and stakeholder involvement in this phase and the completion of usability testing was key for further developments of the prototype.

Figure 7UPA Designing the User Experience- Design Phase with adaptations

As evidenced in Figure 7 above, it was essential to include seven points throughout this phase for the purpose of adapting the framework into one of a multidisciplinary approach. These seven points were focused on formative testing and the methods used to gather feedback from stakeholders and participants along with the requirement for the researcher to up skill and learn programming languages. This was the most important phase for development as there were five versions of the App prior to the implementation phase. Involvement from parents, teachers, SLT's and children with ASD was vital for the development of an App that would meet the needs of end-users.

Prior to beginning low fidelity prototypes, the researcher analysed the data collected in the analysis phase to form a foundation for user requirements. Based on these user requirements, a low fidelity paper prototype of the App was developed. It is essential when engaging in UCD that the researcher receive feedback from stakeholders as early as possible. Thus, when beginning to design paper pencil prototypes it was crucial to liaise with stakeholders. Once the low fidelity prototype was created it was presented to teachers and SLT for feedback. The children were not yet introduced to this prototype as there were concerns that due to their symptomology it may cause frustration and feedback would not be received from them. The researcher completed two iterations of low fidelity prototypes; it was then time to progress onto the development of high fidelity prototypes. The progression to high fidelity prototypes would allow the

researcher to receive feedback of greater depth from children with ASD and their stakeholders.

For the purpose of creating high fidelity prototypes it was imperative that the researcher up skilled to learn programming languages. The Director for Social Services in America (2011), advocates for Social Care Professionals to up skill into the technology world rather than software developers attempting to understand 'our' world. The programming languages that the researcher developed skills in were Html5, Css3 and JavaScript (See section 4.3). This process was undertaken by attending two modules over two college semesters and by completing online tutorials created by the supervisor. The researcher also completed a course in AppInventor (an online open source web application that allows developers to create Android Apps) (Massachusetts Institute of Technology, 2015) to assist in developing programming skills. This process was a steep learning curve for the Social Care Practitioner; however, it also provided great insight into the practicalities of App development. Understanding the computer science discipline was vital for the researcher's development into a multidisciplinary practitioner. It was also a key step for the researcher in managing the expectations of the outcomes of the research and the level of features that could be incorporated into the App. Nonetheless, these programming skills provided the researcher with the foundation to create the first high fidelity prototype.

Formative testing was conducted on the first high fidelity prototype through evaluation by parents and professionals which took the form of a focus group. The dynamics between disciplines brought about great debate around user requirements and resulted in the collection of richer data. The purpose of conducting usability testing with parents and professionals first was to eliminate any significant design flaws that may cause unnecessary frustration or upset for end-users. Parents and professionals are in contact with these children on a daily basis and are the most familiar people with the end users characteristics, likes and dislikes. Therefore, parents and professionals were the most suitable first point of contact for usability testing.

Usability testing was a core component of this phase with five iterations of the App being completed. A sample of end users were involved in usability testing on three occasions. Through the use of observations and usability checklists the end users preferences for functionality became clearer. Parents and professionals were

continuously engaged in this process and an online usability testing session was conducted with them during the summer period. The use of online usability testing facilitated the continuation of a UCD process. Each iteration brought about change with added user requirements at each stage. Once this feedback was received and changes were made to the App to meet the needs of end users, the researcher then began the implementation phase.

4.1.3 Implementation Phase:

As seen in Figure 8 below, the implementation phase focuses on the distribution of the App to end users (Appendix RR). Again, it is evident from the above image that usability testing is of significant importance. However, one aspect that the framework fails to recognise is that of consultation with stakeholders and end users.

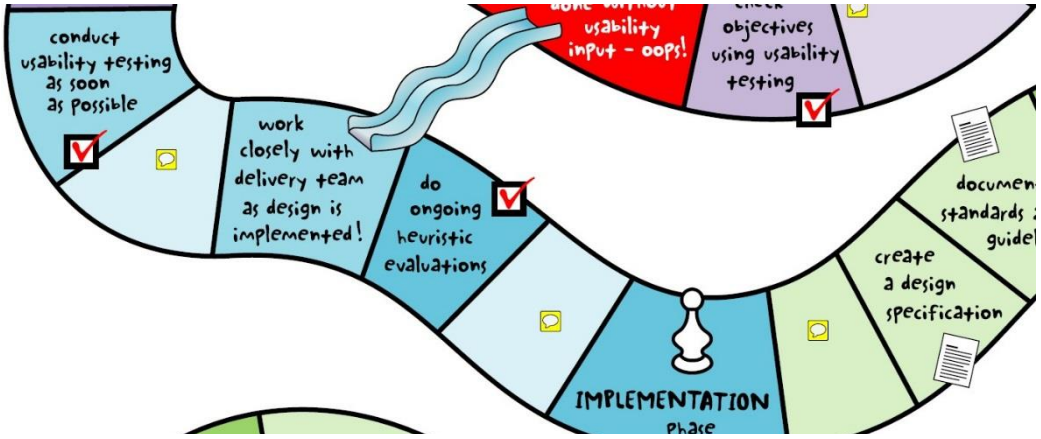


Figure 8 UPA Designing the User Experience- Implementation Phase with adaptations

As a result of the lack of collaboration with end users and stakeholders within the traditional UCD framework, the implementation phase required two key adaptations. These adaptations were key to ensure the successful implementation of the App both in school and at home. Therefore, the introduction of training and support within this framework was essential for both parents and professionals.

A training session was offered to parents and professionals prior to implementation with the children. The purpose of this was to build confidence amongst parents and staff and reassure them of their skills and competence. This training session provided stakeholders with the time to interact with the App and gain fluency in its functionality

prior to engaging with it with the children. During this training session stakeholders were provided with support documentation for the implementation phase. The documentation included:

- A written plan of implementation- this consisted of step by step instructions on how to implement the App and P.E.C.S (See Appendix X). This plan was provided to stakeholders so as to ensure program fidelity.
- A social story for each child- the purpose of this was to aid transition from their P.E.C.S. folder to the App (See Appendix Y).
- A how-to guide- written and visual instructions on the functionality of the App (See Appendix Z).
- A visual support with best practice guidelines for engaging with this type of intervention (See Appendix AA).

When implementing the App with the children the researcher provided staff with hands-on support. For the first week of implementation the researcher was on-site and available to staff if and when they required assistance. This provided staff with reassurance and the confidence they required to ensure successful implementation with the children. The researcher again engaged in formative testing by conducting usability testing with the children during this first week. Once the children, parents and professionals were comfortable with this new system the researcher began the deployment phase.

4.1.4 Deployment phase:

As seen in Figure 9 overleaf, the deployment phase focuses on evaluation, modifications and achieving objectives. This phase utilises a variety of tools in order to collect data, for example, surveys and field studies.

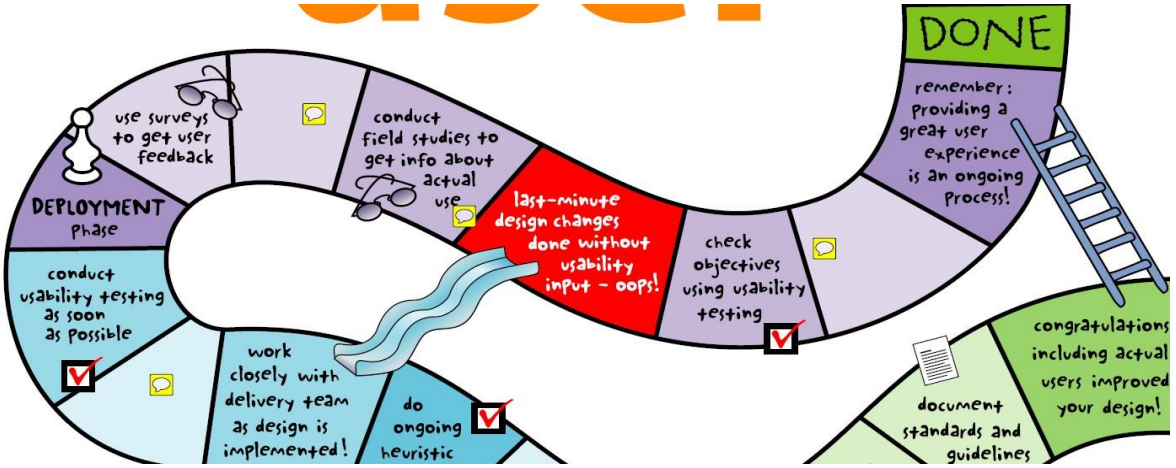


Figure 9 UPA Designing the User Experience- Deployment Phase with adaptations

As highlighted in Figure 9 above, in order to complete a multidisciplinary project there were three adaptation required for this phase. These adaptations focus on two areas: feedback and effectiveness.

The deployment phase focuses on end user feedback using surveys; however, as a result of the end users being children with ASD it brought about complications to using this method. The majority of children in this research did not yet have the ability to read and in addition, the symptomology of ASD highlights that they experience limitations in attention span. Thus, the use of surveys was unrealistic and would potentially cause frustration for participants. Due to the symptomology of children with ASD the use of surveys would have run the risk of collecting data that was inaccurate due to misunderstanding of questions or lack of focus on questions. The adaptation that was required here was to utilise a method that participants were familiar with.

Best practice guidelines for communicating with children with ASD state that messages should be short and concise (Crissey, 2009); therefore, the researcher followed this ethos. The researcher utilised a metaphor that was most familiar to participants to gain feedback about the App; P.E.C.S. Participants were presented with a choice board and a laminated symbol of the user interface of the App. The teacher/Special Needs Assistant (SNA) asked the child "do you like your App?", children were presented with a happy and sad face, as this was the vocabulary they were familiar with, and chose accordingly. This alternative system empowered the children to give basic feedback to the researcher and to highlight their

preferred choice of communication system. The use of an alternative system, familiar to the children, assisted in reducing anxiety levels that may be caused when introduced with a more complex feedback system such as interviews and surveys. The symptomology of ASD does not support traditional feedback methods; thus, it was essential to adapt the methods to meet the needs of the participants.

The next step that needed to be added to this framework was that of summative testing; data collection. The researcher implemented three tools that facilitated data collection in the areas of effectiveness and modifications. The researcher utilised the Autism Treatment Evaluation Checklist (ATEC), observations and usability testing so as to collect data on the effectiveness of the App for the children. The ATEC and observations provided a map for each child in relation to progress. This progress was evident through both quantitative (ATEC) and qualitative (observations and comments from stakeholders) methods. The ATEC was completed by the researcher during observations and was scored later that day using the Autism Research Institutes online database. The observation checklist was developed on foot of informal observations and continued to reflect the categories being investigated (See Appendix BB). The observation checklist provided the researcher with a tool that was reflective of the data collection requirements; but, increased the scope of data collection. Formative testing was again employed within this phase through another usability testing session. As a result of the use of usability testing the researcher gained insight into aspects and features of the App that required changes or adaptations. Through the use of both of these tools the researcher had the ability to track a child's progress on a fortnightly basis.

The final step that was added to the deployment phase was that of stakeholder data collection. The researcher administered two questionnaires to parents and professionals with the aim of collecting data in the areas of usability testing and effectiveness. One questionnaire was administered prior to mid-term break (late October) with the aim of collecting data for potential modifications to the App (formative testing) (See Appendix CC). The second questionnaire was administered at the end of the intervention (late December) with the aim of establishing the effectiveness of the intervention (summative testing) (See Appendix DD). This step was essential for triangulation and also for recommendations for future development of the App. It is clear from the diagram above that this is the final phase of the UCD process; however, on the

final step of the process is a ladder. This ladder is an indicator and a reminder that the UCD process is an iterative one by guiding the developer/researcher back down the ladder onto the design phase.

In conclusion, the UPA designing the user experience diagram is a useful tool when designing *for* children with ASD; however, when taking into account the ethos of UCD, it is essential to design *with* children with ASD. The involvement of end users and stakeholders in the design process is vital so as to develop software and Apps that meets their needs. This research has developed adaptations to incorporate into this framework that facilitate multi-disciplinary partnerships for future technological developments in the area of health and social care informatics.

4.2 Standards

There are many definitions available for standards; however, they all uphold mirroring ethos's. Autry and Killam (2016), define a standard as 'something, such as a practice or a product that is widely recognized or employed, especially because of its excellence' (pg. 3). While the International Organisation for Standardisation (ISO) (2016), defines a standards as 'world class specifications for products, services and systems, to ensure quality, safety and efficiency' (pg. 1). In its most basic form a standard is an agreed way of doing something with the aim of increasing accessibility (BBC, 2016). This accessibility is achieved by using a standard that works across multiple platforms and in different countries (BBC, 2016). The purpose of standards are to:

- Allow products to relate to each other,
- Abide by and satisfy legal requirements,
- Promote quality and consistency among developers,
- Implement best practice guidelines and
- Create a product that is usable.

(Autry and Killam, 2016)

These standards are not only utilised by programmers but also by professionals involved in several aspects of the design and development of a product. For example, human factors specialists, graphic designers, software analysts and managers, to name but a few (Autry and Killam, 2016). These standards can be utilised throughout the

lifespan of a product; however, they are primarily used as an aid during design (Mosier and Smith, 1986).

There are many types of standards available and for many purposes, for example, safety, performance, user interface and functionality (Autry and Killam, 2016; Nielsen, 1991). However, as stated by Nielsen (1999), standards can be difficult to implement due to misinterpretation of standards and gaps in the standards. As a result of the end-user group in this research and the specificity required for development the researcher utilised best practice guidelines as opposed to standards throughout the UCD process. The best practice guidelines that were utilised were developed specifically for designing and developing with people with disabilities and with ASD. Some of the best practice guidelines that were utilised during the development of the App include:

- National Autistic Society (2015),
- Web Content Accessibility Guidelines, W3C (2013),
- Guidelines for Application Software Accessibility, National Disability Authority (2014),
- Web Accessibility Techniques, Centre for Excellence in Universal Design, National Disability Authority (2014)
- IBM Human Ability and Accessibility Center (2014).

A review of the literature also provided the researcher with best practice guidelines for the purpose of design and development with children with ASD and their stakeholders. A review of twelve research articles (See Appendix EE) contributed to the above guidelines when designing with children with ASD. These guidelines informed both the design and development of the App throughout the duration of this research.

4.3 Continued Professional Development: Html5, CSS3 and JavaScript training

As a result of the skillset held by the researcher it was essential to engage in continuous professional development (CPD). The researcher is a Social Care Professional and did not possess any programming skills or experience prior to commencing the research. In order to have the ability to develop a communication App with these

children the researcher learned three programming languages: HTML5, CSS3 and JavaScript.

The researcher engaged in 12 weeks of lectures where HTML5 and CSS3 were taught simultaneously. These languages form the basis for the aesthetics of the user interface. HTML and CSS are part of the web based standards approach. This approach focuses on the use of well-structured HTML to mark-up content and CSS to control presentation (Murphy et al., 2012). These web based standards were developed with the aim of creating consistency for developers and users. As a result of developers utilising these languages, users received the benefit of accessibility i.e. they could access content appropriately from multiple devices and platforms. As stated by Meyer (2011), HTML 'holds the content for the website, with tags providing information on the nature and structure of the content as well as references to images and other media' (pg. 1). While the purpose of CSS is to specify the formatting (Meyer, 2010).

The researcher then continued on to complete a course in AppInventor. This occurred during the month of December with the purpose of serving as a bridging course to prepare for JavaScript. AppInventor is an online tool that guides students through the knowledge and practicalities of developing Android Apps. During this course the researcher created Apps such as quizzes and basic games. These online tutorials assisted the researcher in transitioning to the JavaScript module.

For the second semester, which consisted of 12 academic weeks, the researcher began learning JavaScript. JavaScript is a 'programming language that's used to make the web site dynamic and interactive' (Meyer, 2010, pg. 1). The researcher utilised JavaScript within the App to add features such as the cancel and expand buttons and the activation of the content of the categories when clicked on by the user.

This was a steep learning curve for the researcher and with no prior knowledge in this area it was a challenge from beginning to end. However, as a result of engaging in this process the researcher gained insight into a new discipline which resulted in appreciation and knowledge attainment. As a result of engaging in this process the researcher now had the skills to liaise with computer science professionals in future collaborations. After eleven months of programming the researcher was successful in

developing into an independent multidisciplinary professional by completing the development of the App.

4.4 Web App

There are many definitions available to define a Web App; however, they are based on two basic principles. Firstly, a Web App is defined as 'an application program that is stored on a remote server and delivered over the internet through a browser interface' (Rouse, 2011, pg. 1). Secondly, a Web App is developed through HTML5, CSS3 and JavaScript (Davis, 2016). Due to the limited programming skills of the researcher, the use of Web Apps was inevitable. The use of Web Apps was the most pragmatic solution available to the researcher given the time and resources available. As outlined in the previous section, the researcher has a total of two college semesters to learn programming languages that would provide the skills to produce an App that was functional and end-user led.

The researcher began creating high fidelity prototypes upon completion of two cycles of obtaining user requirements and one cycle of low fidelity prototypes. The purpose of developing high fidelity prototypes was to generate the development of more in depth user requirements. The researcher hosted the Web App on a free online web hosting site and had the ability to demonstrate and test the App with children and stakeholders. The use of the online web hosting site provided the researcher with an accessible platform to demonstrate and test the App in a time effective and simple manner. This allowed the researcher to engage in rapid prototype development. When the researcher was incorporating new user requirements into the App, the online hosting provided a platform where changes could be observed instantaneously. This was a catalyst for developing versions of the prototype rapidly. One limitation to utilising this approach was the requirement for access to internet from the school. This issue occurred when the researcher was conducting usability testing sessions with stakeholders and participants. However, this obstacle was overcome through the use of a mobile Wi-Fi dongle. This dongle provided the researcher with internet access while on site and facilitated the conducting of usability testing within the participant's classrooms. As a result of utilising a Web App approach the researcher had the option to deploy the App

on either Android or iOS based devices. The decision to use either Android or iOS devices was dependent upon the end users; thus, this could not be finalised by the researcher until later in the design phase.

4.5 Early versions of the App: From 'Hello World' to Onei

This section aims to provide a brief overview of the development of the features of the App (Onei) and to provide justification of each step in the development phase. Each iteration was based on formative testing with the collection of user requirements and compliance with the UPA Designing the User Experience framework (See Appendix FF). This section identifies why and how certain features changed and evolved over the course of the design and development phase. The features that are discussed include: colour scheme, image styles, layout of the interface and categorisation of images.

The name of the App was developed during the design phase and was based on two ideas. The researcher wanted to uphold the ethos of user-centred within the Apps name and also wanted to highlight the uniqueness of each individual participant along with empowering independence. The name of the App was developed by the principal supervisor Dr. Tom Farrelly. Dr. Farrelly derived the name from the researcher's surname as Gaeilge (O' Shuileabhain) while upholding the ethos the researcher had previously outlined. The name of the App became Onei; one focusing on individuality and 'i' focusing on independence within each person. The design of the logo is also reflective of this ethos.

Figure 10 App Logo

Upon collection of initial user requirements (through the use of interviews and participant profiles), the researcher developed the first high fidelity prototype. This first version was evaluated by stakeholders (parents, Speech and Language Therapists and classroom teachers) during a focus group session. The features included in this version are outlined below and the justification for inclusion is provided through evidence, stakeholders and participants.

4.5.1 Version one:

Table 5 Version one features

Feature:	Literature Evidence:	Participant/ Stakeholder Evidence:	Comments:
Colour Scheme (light yellow #FFFFEB)	National Autistic Society (2015)- Best practice guidelines	Stakeholder interviews: stakeholders were unsure if participants presented with sensitivity to colour contrasts.	For children with ASD, the contrast of black on white holds the risk of being visually over stimulating (sensory processing).
Image styles	National Autistic Society (2015)- Best practice guidelines	Stakeholder interviews: stakeholders requested a mixture of symbols and photographs- to promote personalisation.	
Swiping on sentence strip to delete images	Sesame Workshop (2012); White (2016)		

Feedback received from the focus group session resulted in some user interface developments which were incorporated into version two of the App. In particular, the image styles were an important feature for stakeholders; the transparent background proved effective for eliminating the risk of distraction and increasing focus on the symbol. The figure below provides a description and justification of features incorporated in version two of the App.

4.5.2 Version two:

Table 6 Version two features

Feature:	Literature Evidence:	Participant/ Stakeholder Evidence:	Comments:
Sentence Starter division	Schneider (1996), suggests that when an image is displayed continuously on screen it causes confusion for children.	Speech and Language Therapists	Sentence starters include want, see, hear. The aim of this was to encourage children to begin sentence structure.
Basic needs division	See above.	Parents	Basic needs include toilet and drink. Requested to have basic needs displayed at all times so as to provide instant access when required.
Image styles		Stakeholder focus group: images with transparent background were preferred as the image was more prevalent and not as distracting in comparison to images with a white background.	
Colour Scheme	National Autistic Society (2015)	Stakeholder focus group: positive comments made on the low contrast between images and background.	

Version two was tested with three of the children (see section 4.6). The results and feedback received from the usability testing session informed the development of version three.

4.5.3 Version three:

Table 7 Version three features

Feature:	Literature Evidence:	Participant/ Stakeholder Evidence:	Comments:
Categories:	Frost and Bondy (2002) support the use of categories in P.E.C.S.	Stakeholder focus group: expressed the need for categories; however, requested all content be displayed upon initial loading of the App. Participant usability testing: participants navigated the categories independently.	The purpose of loading all vocabulary content when the App is opened avoids the risk of some children not yet having the ability to navigate categories.
Category structure: cookies vs. divisions vs. slider	National Autistic Society (2015)- Best practice guidelines.	Stakeholder interview: 'if there are too many steps to get to the vocabulary they are seeking they will just stop using it [App]'.	Accessibility to vocabulary was key for participants.
Sentence Structure vs. Communication	Frost and Bondy (2002)	Feature analysis of existing Apps by researcher: findings showed that current Apps available do not incorporate a feature that distinguishes sentence structure from communication.	P.E.C.S. protocol states that a child must exchange the symbol to a communicative partner for communication to take place.
Two buttons (replacing swipe gestures)	Stromen (1994); Bederson et al. (1996); Hourcade et al. (2004); Inkpen (2001); Lazar (2007).	Stakeholder interviews: participants mostly use the iPad for youtube; thus, are familiar with the functionalities of buttons. Participant usability testing: swipe gestures were difficult to navigate; however, when	An expand and cancel button were incorporated (familiar with functionalities of youtube) into the sentence strip so as to delete images and
Colour Scheme	National Autistic Society (2015)- Best practice guidelines	Participant U.T. session	Researcher noted the change in interactions with the App amongst participants when presented with two different coloured backgrounds.

The incorporation of categories brought about difficulties when programming the App. Many different options were considered for the programming of this feature; such as the use of cookies, hiding divisions and only displaying them when an onclick was

activated and the use of frameworks (e.g. sliders). Cookies are used for the purpose of storing values and remembering your last movements on a browser. The issue arose that when creating a sentence and searching multiple categories the data in the sentence strip was lost. The storing of data in the sentence strip was essential; therefore the use of cookies was a potentially viable option.

Each of the three options mentioned above were evaluated in relation to the needs of the children and in accordance with best practice guidelines. The use of cookies was eliminated due to the fact that it would involve the user engaging in more clicks that is necessary and it would make the process of creating a sentence more complex for the children. As stated by one of the stakeholders in an interview, 'if there are too many steps to get to the vocabulary they are seeking they will just stop using it [the App]'. The second option of manipulating divisions to appear using an event handler was made obsolete for two reasons: it is not the most appropriate way as per programming best practice guidelines and it would bring about issues when importing the camera feature as storing the new images would become an issue. As a result of this, the researcher decided to use a slider. This slider provided a template that allows categorisation of images without the requirement of loading a new page each time a user clicks on a category. The use of a slider allowed for the structure/layout of the App to be located on one index.html; thus, allowing the data in the sentence strip to remain static.

As previously stated, the colour scheme of the App required attention to detail for the purpose of meeting end-users needs. During this U.T. session the children were exposed to two versions of the App. The functionality was exactly the same; however, the background colour was different. One had a white background and the other had a grey background. This approach was taken so as to gather data in the area of sensory processing. Best practice guidelines state that the contrast of black on white for some people with ASD causes items to appear as if they are moving on screen; thus, effecting their concentration (National Autistic Society, 2015). The effect of this on participants was immediate. Participants appeared confused when presented with the white background and it took them longer to complete tasks that they had just completed independently using the prototype with the grey background. Version four was refined and consisted of the features outline in the following table.

4.5.4 Version four:

Table 8 Version four features

Feature:	Literature Evidence:	Participant/ Stakeholder Evidence:	Comments:
Categories	Frost and Bondy (2002)	Stakeholder focus group and usability testing with participants.	As a result of engaging in the development of several iterations of the App end-user feedback evidenced successful navigation of the categories.
Audio for images and categories	Walsh and Barry (2009)	Stakeholder interview evidenced that a child was learning vocalisation of words from an App; however,	The use of a local voice was key so as to encourage pronunciation of words in a familiar tone. Audio was implemented for each image within the App.
Full screen button	Frost and Bondy (2002)	Participant usability testing and stakeholders (see version three table for more information).	To distinguish between sentence structure and communication.
Cancel button	Inkpen (2001)	Participant usability testing.	To remove images from the sentence strip.

As the summer holidays were approaching the researcher decided to offer online U.T. sessions to teachers, SLT's and parents in order to continue data collection. Version four was evaluated by stakeholders through online U.T. during the month of July. Participants were given an online link to access a webpage resembling the App and its current functionality. Participants were requested to complete a feedback questionnaire which would allow the researcher to identify more user requirements (See Appendix J). These requirements were then incorporated into the App to formulate version 5 of Onei.

4.5.5 Version five:

Table 9 Version five features

Feature:	Literature Evidence:	Participant/ Stakeholder Evidence:	Comments:
Categories	Frost and Bondy (2002)	Stakeholder focus group, stakeholder completion of vocabulary checklist for each child and participant usability testing.	Categories were implemented and vocabulary was developed based on data collected from teachers, SLT and parents.
Audio	Sigafoos et al. (2014); Walsh and Barry (2009)	Stakeholder interviews and focus group.	Local voice was preferred.
Sentence Strip with functionality	Stromen (1994); Bederson et al. (1996); Hourcade et al. (2004); Inkpen (2001)	Participant usability testing.	Expand and cancel buttons.
Images	Lazar (2007); Sigafoos et al. (2014)	Stakeholder interviews and focus group.	Symbol set that is not abstract was requested. Sourced from TalkSense. Size of images were 100px so as to ensure compliance with best practice guidelines.
Camera	Campigotto et al. (2013); Nagurski (2010)	Stakeholder focus group.	Parents requested control over the camera function; however, this was beyond the skill set of the researcher and would conflict with the ideology of creating independence in managing vocabulary for participants.
Colour Semantics	Goossens et al. (1992)	Speech and Language Therapists	Colour coding of each image to categorise them into verbs, nouns, etc.

Version five was implemented with participants from October 2015 to December 2015. Prior to mid-term break the researcher engaged in another iteration of UCD by collecting more user requirements. The researcher conducted U.T. with participants and provided stakeholders with an evaluation questionnaire to complete (See Appendix CC).

An in-depth account of the results and findings of this intervention are presented in Chapter five. As previously stated, the incorporation of these features were derived as a result of engaging in usability testing sessions with participants and stakeholders (Appendix SS). The following section presents the planning, implementation and results of the usability testing sessions conducted throughout this research.

4.6 Usability Testing with Children with ASD

Due to the complex nature of ASD, usability testing (U.T.) with the children with ASD is essential for two primary reasons; to ensure that frustration and errors are minimised for them when they are engaging with new software or applications and to ensure that their needs are being incorporated into the development. As stated by Varnagy-That (2015), few researchers have conducted U.T. with children with ASD; however, with a few extra preparations the process can be conducted successfully. When conducting U.T. with children with ASD, prior consideration must be given to a wider range of topics as opposed to generic U.T. (Zaman and Bhuiyan, 2014). This consideration is applicable to the planning, design and implementation stages of the U.T. session. The planning stage is central in order to identify the foundations of working with children with ASD. There are four primary aspects that need to be given consideration prior to conducting U.T.'s with children with ASD: determining participant characteristics, choosing the best location, scheduling the right amount of time and recruiting participants with ASD.

As previously outlined in this dissertation, ASD is based on a spectrum; thus, when identifying characteristics of people with ASD some generalisations need to be drawn upon. As outlined by the DSM-5, ASD consists of social and communication impairments and restrictive and repetitive behaviours. However, within these categories there are specific elements that effect children in different ways. For example, in relation to sensory processing some children may engage in particular behaviours if there are loud noises in their environment, while another child with ASD may engage in particular behaviours if there is a certain smell in the environment. As previously stated, children with ASD may experience difficulties in the area of communication; therefore, alternative methods are required. The use of observations is crucial in this instance with non-verbal

communication playing a significant role in attaining usability insights (Varnagy-Toth, 2015). The need for the development and use of participant profiles was evident here as the researcher was able to effectively plan the session while taking each child's characteristics into account.

The second practicality that required consideration was the location of the U.T. session. Rubin and Chisnell (2008), recommends that when conducting U.T. with people with disabilities the session should take place where the users will most often interact with the technology you are testing. In light of this and considering the children's individual needs, U.T. sessions were held in the participant's natural setting (school classroom). This was a viable option for the researcher and it also assisted in over-coming any of the obstacles that have previously been outlined (e.g. sensory processing). The use of natural environments provided the researcher with greater control in eliminating unexpected sensory stimuli for the children. Lowdermilk (2013), states that conducting natural setting U.T. sessions provides for a study that is more focused, systematic and consistent.

When conducting U.T. sessions with children with ASD the length of time for the session and the number of participants are other factors that need to be planned for (IBM, 2014). A common characteristic among children with ASD is a short attention span; thus, reducing the length of time for the session is essential. Rubin and Chisnell (2008) and IBM (2014), highlight that people with disabilities may get tired easily or may need breaks between tasks. Best practice guidelines state that 20 minutes is a sufficient amount of time for any U.T. session; thus, planning a U.T. session lasting 10 minutes for children with ASD is justifiable. The number of participants within a group would also impact on a child's attention span as some children with ASD are intolerant to waiting. The rule of thumb for conducting an effective U.T. session is to abide by the 'no-more-than-five' rule (Lowdermilk, 2013, pg.98). Wakeel et al. (2015), states that 'because 5-6 participants will find 80% of usability problems, there is little additional benefit to running more than 5-6 people through the same study' (pg. 205). The IBM (2014), also confirms this by outlining that 3-5 participants is sufficient for U.T., irrelevant to ability or disability. With all of these considerations in mind, a group of three children were chosen to engage in a U.T. session. Children were selected using nonprobability sampling (Trochim, 2016). This method was chosen upon consultation with the classroom teacher

as this group work very well together during circle time. The three participants sit together for approximately 20 minutes each morning and engage with each other using activities and songs. The three participants had limited verbal abilities; thus, the researcher had to explore appropriate methods to collect data from the children. Many studies use children as testers for products and provide a framework for this (Markopoulos and Bekker, 2003); however, it is much more difficult to engage in this process with children with ASD.

This difficulty arises as a result of the symptomology of children with ASD; for example, communication difficulties, limited social engagement, decreased levels of attention span. As a result of the fact that these three children were in attendance in the same classroom; the risk of distraction and anxiety that may have been caused by formulating a group of participants from several classrooms was automatically reduced. Another variable that required thought is the person leading the U.T. session. It is traditional for the researcher to facilitate the session (Rogers et al., 2011); however, when engaging with children with ASD it is important to be paired with a child (Leaf and McEachin, 1999). The process of pairing is an ABA concept that focuses on building a rapport with children prior to placing any type of demand on the child e.g. requesting them to follow instructions or answer a question (Leaf and McEachin, 1999). In order to over-come this obstacle the classroom teacher led the session as the child is familiar with them and children with ASD show preference to interacting with people they know (Wakeel et al., 2015). Weiss et al. (2011), adapted this ideology by using Occupational Therapists in their study, whom the children were familiar with and engaged with on a regular basis. The evidence showed that this approach eliminated any anxieties that could possibly be caused by interactions with unfamiliar people.

The classroom teacher was provided with a set of step-by-step instructions on running the U.T. session (See Appendix GG) a week prior and was also provided with a script (See Appendix HH) to utilise so as to ensure consistency and validity in the data collected. The use of the script provided the teacher with clear instructions on how to prompt participants for responses without leading participants to elicit a specific

response. The researcher adapted the role of observer during the U.T. sessions and also completed U.T. evaluation checklists (See Appendix II) so as to receive feedback and results. The development of the U.T. evaluation checklist was underpinned by the usability goals (See Appendix V) through utilising the Five E's framework. The Five E's were developed as a tool to determine the how usable a product is from the users perspective (Rogers et al., 2011). The Five E's include: effective, efficient, engaging, error tolerant and easy to learn (Quesenbery, 2004).

Table 10 The Five E's Framework for Usability Testing

Term	**Description**
Effective	'addresses whether the software is useful and helps users achieve their goals accurately' (pg. 5).
Efficient	The speed in which tasks can be completed.
Engaging	'how pleasant, satisfying, or interesting an interface is to use' (pg. 5).
Error Tolerant	'how well the product prevents errors and helps users recover from any errors that do occur' (pg. 5).
Easy to Learn	'how well the product supports both initial orientation and deeper learning' (pg. 5).

Upon engagement with this framework, it became clear to the researcher that this framework also required adaptation to meet the needs of the end-users. For example, error-tolerant involves deliberately setting up a scenario of an error and measuring how the participant over comes the error and how they react to the error. However, due to the symptomology of end-users this is not possible to conduct for two reasons: ethics and theoretical knowledge of the metaphor being used. Children with ASD hold a high risk of reacting negatively to an unexpected event. Creating a scenario of error holds the potential to result in causing stress and upset to a participant and potentially resulting in an outburst of behaviour that challenges. This in itself would be unethical; to set a child up for such distress. The theory behind the metaphor (P.E.C.S.) is Applied Behaviour Analysis (ABA). This theory focuses primarily on error-less learning by providing children with direct positive reinforcement and by setting the children up for success. Thus, to set a participant up for an error would be conflicting the ethos of the metaphor being utilised in this research. Overcoming this for the purpose of U.T., was done by observing participants removing an error picture/symbol caused by themselves from the sentence strip.

Individual results of the U.T. sessions with participants are presented in chapter 5 and highlight the heterogeneous needs of end-users. The results of the U.T. sessions were incorporated into the development of future prototypes so as to ensure a UCD process was being adhered to. Some of the features outlined in the previous section were derived as a result of direct U.T. sessions with participants. For example, the colour contrast within version three that was explained earlier.

In conclusion, the use of traditional U.T. methods were not applicable to children with ASD due to their symptomology. Therefore, adaptation of these traditional methods was necessary to provide participants with a more meaningful role in the process. In light of the evidence presented in this section, there are four steps that are significant when conducting effective U.T. sessions with children with ASD:

- Follow best practice guidelines and make the process as comfortable as possible for participants,
- Adapt traditional usability testing methods so as to ensure that the research is continuing to uphold a user-centred design,
- Ensure that the session is planned in order to meet the diverse needs of the children with ASD and
- Finally, remember to observe behaviours and communicate with participants to extract richer data.

4.7 App Features:

During the design and development of the App there were several features that required extra consideration. These features included: sourcing images/symbols, screen layout, organisation of categories, voice and device type. This section aims to provide a brief summary and justification for the actions taken in the deciding of these factors.

4.7.1 Sourcing images

There are a plethora of symbol sets available for parents and professionals to choose from when implementing P.E.C.S. with children with ASD. Some of the many symbol sets available include: SymbolStix, Mayer-Johnson, Pics for PECS, Picto Selector and TalkSense. The cost of these symbols varies from free to £69.60[10] (€90.96). The costing brings with it many risks; the perception that because it costs more it is better and the use of multiple sets of symbols with one child. When choosing a symbol set for a child/children it is essential to first look at their needs with the symbol set being matched to the child (Glennen and DeCoste, 1997). Symbols should be meaningful to the children; not to the adult choosing them. For example, below are three images with the same meaning; however, each one of us may see different meanings and label them differently.

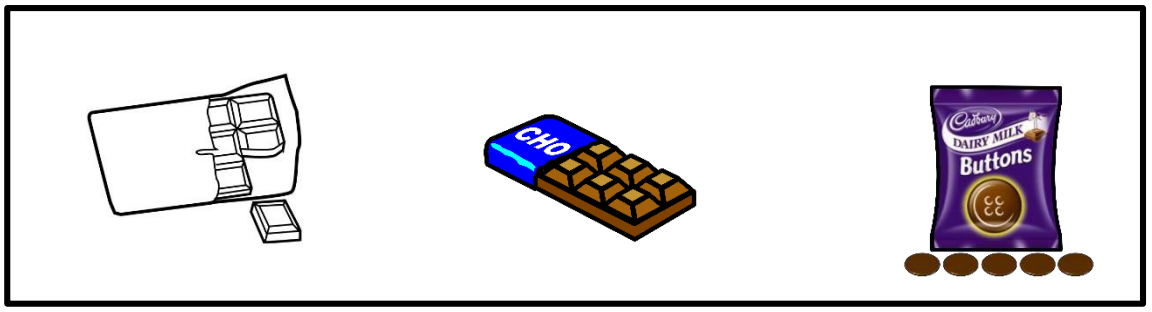


Figure 11 Examples of different symbols which have the same meaning

Thus, prior to implementing a symbol set the needs of the children needed to be evaluated. The participant profiles and stakeholder interviews were key tools in this process. The researcher identified the needs of participants by utilising the hierarch of symbols.

Mirenda and Locke (1989), developed a hierarchy which aims to categorise symbols on the basis of being most iconic to least iconic. This theory is associated with Speech and Language Therapy (SLT) pathology and provides a guide to identifying a symbol set that best suits the needs of the end-user. The more iconic a symbol, the easier it is to learn (Glennen and DeCoste, 1997).

[10] Converted on 04/02/2016 @ 1:1.31

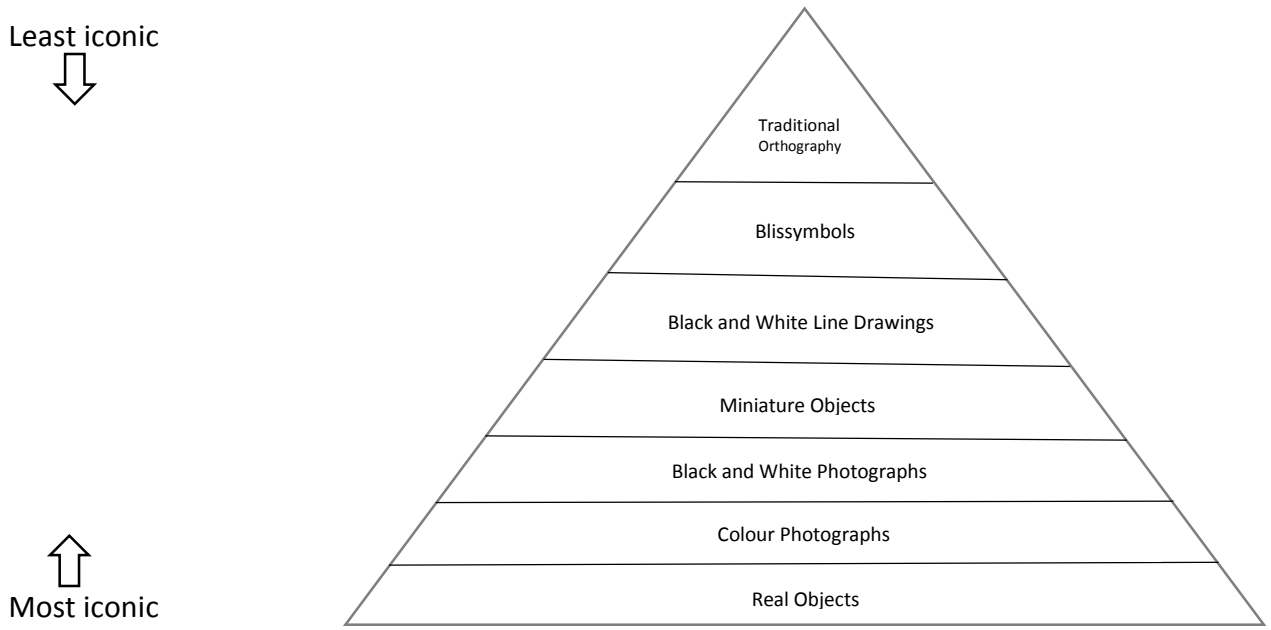


Figure 12 Speech and Language Hierarchy of Symbols

Upon interviewing the parents and professionals it became evident that there were challenges with available symbol sets. The interviews highlighted two primary issues in relation to sourcing of images: 1) inconsistency of symbol sets and 2) some symbols were not applicable to an Irish context. The use of symbol sets were inconsistent not only between home and school but also within each setting independently. From the interviews conducted by the researcher, parents and professionals reported that the children do not use the same symbol sets at home as they do in school. The lack of consistency in relation to symbol sets was also reported to be due to the fact that some sets do not provide all the required vocabulary and some images are too abstract. One stakeholder commented during an interview - "often with some of the P.E.C.S. symbols they don't make sense to me". As a result of this, parents and professionals need to source their own image of the item; thus, resulting in the use of a new symbol set. The development of Irish based symbols was also a challenge for parents and professionals. Professionals reported that images such as the Irish flag, our holidays (i.e. St. Patricks Day) and transport were not available within the symbol sets. One stakeholder stated "our bus isn't always yellow" [yellow bus symbols is derived from

American culture]. This highlighted the need for the sourcing of images that would meet the needs of the participants.

When the professionals had completed the participant profiles the researcher began sourcing a symbol set that would be most appropriate. It was clear from the evidence gathered that the participants were at varying levels within the symbols hierarchy; however, they had all at least reached the colour photograph phase. The researcher evaluated symbol sets first based on the needs of the participants and finally based on cost. The researcher decided that the most appropriate symbol set available that appeared to meet the needs of the children was the TalkSense Symbols. The researcher contacted the designer of the symbols to receive permission to use them for the development of the App. Mr. Tony Jones (the designer) granted permission for the use of the symbols without any cost. The symbol set was shown to parents and professionals prior to implementation all of whom agreed that the symbols were most suitable. Mr. Tony Jones provided the researcher with the vocabulary required by the children as identified in the participant profile. He also facilitated the researchers request to make changes to symbols so as to make them more appropriate to an Irish
context (e.g. taytos vs. crisps). The following are examples of TalkSense symbols.

Figure 13 Examples of TalkSense Symbols

4.7.2 Screen layout

The layout of these symbols on the screen/user interface was a topic that was addressed at the focus group with parents and professionals. Suggestions arose in relation to this; however, they were discarded based on evidence. For example, there was a suggestion for the inclusion of a variety of verbs (want, see, hear) to be located in the left corner of the screen. However, this was eliminated on two grounds: 1. only a small

number of participants had commenced using “I want” in their sentence structure; thus, this was not a need of end users and 2. This would conflict with the theory of P.E.C.S. The metaphor being utilised for this research was P.E.C.S.; thus, it was vital to ensure that the theoretical approaches to this system were abided by and implementedthroughout. Therefore, it was decided that the screen layout/user interface would be displayed using categories. The categories and the content of the categories were informed by end-users through the participant profile. The screen layout consisted of:

- Categories along the top (including a button for the camera function),
- The content of the categories in the middle of the screen and
- The sentence strip located at the bottom of the screen.

Figure 14 Screenshot of the User Interface of the App

The use of categories facilitated the development of a user interface that was free from clutter and distraction. This was an important feature to consider due to the symptomology of children with ASD and also to abide by best practice guidelines. Pagani Britto (2015), stated in their guidelines for best practice that a simple interface with few elements is essential in meeting the needs of children with ASD during App design.

4.7.3 Categories

The use of categories in the App was established based on P.E.C.S. protocol. As stated by (Frost and Bondy, 2002), the categorisation of symbols is important for children with ASD. The layout of traditional P.E.C.S. folders also follows categorisation by usingdifferent colours for each new page within the folder. This layout was adapted within the App so as to create familiarity and consistency for participants. If the researcher had deviated from a categories layout it may have caused upset for participants. The symptomology of ASD does not support changes in routine; instead familiarity is preferred.

4.7.4 Voice

The use of voice output has been discussed throughout the literature and has been highlighted as a beneficial feature in AAC Apps (McEwen, 2010; Sennott and Bowker, 2009; De Leo et al., 2009). One of the primary myths surrounding voice output has been debunked by theorists (Sennott and Bowker, 2009). It has been claimed that the use of voice output inhibits the development of speech in children with ASD; however, research has shown that it is in fact the opposite (Sennott and Bowker, 2009). The use of voice output creates consistency within the P.E.C.S. protocol by eliminating the risk of human error. P.E.C.S. protocol states that when a child is engaging in communication and exchanges a symbol with a communicative partner, it is the role of the communicative partner to verbalise the label of the symbol (Frost and Bondy, 2002). However, this aspect has the potential to be lost amid the exchange with the communicative partner focusing more on giving access to the requested item. As a result of the strong evidence for the use of voice output it was decided that it would be included within the features of the App.

The researcher addressed the topic during interviews with staff and parents to establish their views on generic voice vs. local accent. The interviews evidenced that the majority of stakeholders would prefer a local voice as opposed to a generic one. One stakeholder stated “[participant] has been using an App to learn words but she sounds American. It’s an American accent in the App.” The use of a local voice would provide the children with the opportunity to learn the pronunciation of vocabulary that was familiar to their family, peers and community; thus, promoting inclusion. It was decided that the

Principal of the school (who had just retired) would be the person to record the voice output. The voice recordings were completed at the Institute of Technology Tralee and were coded into the App by the researcher

4.7.5 Camera feature

The decision to incorporate the camera feature was taken for two reasons: the strong evidence in the literature and to meet the needs of end users. As previously outlined in Chapter 2, the opportunity for children with ASD to develop and manage their own vocabulary manifests in the development of their independence (Nagurski, 2010). The camera feature is an essential tool in providing this opportunity as children with ASD can develop symbols to add to their vocabulary 'on the fly' (Harrell, 2010). Within a few seconds a child can develop a symbol that they require immediately and can instantly use it to convey a message. The additional benefit to this is the reduction of frustration; thus, decreasing behaviours that challenge. The development of one's own vocabulary is an empowering process; especially when that person has been dependent upon others to pre-empt and develop it for them for some time previous. The needs of the end users remained at the forefront of this research.

As there was such a diverse range of needs amongst participants the inclusion of all vocabulary required by each individual was a task that was beyond the scope of this project. The researcher created a bank of symbols that were most commonly used by the majority of participants and coded them into the App. The children and stakeholders could then personalise each App through utilisation of the camera feature. Thus, meeting the needs of each individual child while making the App personal to them. Research has shown that children with ASD showed preference to using their own personalised symbols versus using generic symbols (De Leo et al., 2010). Prior to implementation of the App, stakeholders were given training on the use of the camera feature. The researcher also provided them with visual instructions via the how-to guide and the implementation plan.

As the researcher has a background in social care practice and prior to the research did not possess skills in the area of computer science, a collaboration approach was taken to develop the camera feature. The researcher collaborated with Mr. Keith O Faolain at IMaR (Intelligent Mechatronics and RFID Technology Gateway) at the Institute of Technology Tralee to program and implement the camera feature within the App. Once

this was completed, the researcher uploaded the code to PhoneGap so as to create a hybrid App that would deploy on the iPad's.

4.7.6 Selecting mobile devices

In order to carry out this research effectively it was essential that each child would be given their own mobile device for the duration of the data collection phase. It is best practice to conduct evidenced-based assessments for each child for the use of either Android Tablets or iPads; however, in order to provide validity in this research device consistency was required. Children react differently to different mobile devices and operating systems, particularly if they are unfamiliar with the system (Booth, 1989); thus, the researcher had to ensure that this would not impact upon the data collection which was focused on the effects that the App had on the participants. The researcher chose the mobile devices based on usability and familiarity.

The researcher conducted usability testing on an Android Tablet and an iPad. In order for the children to access the App on the Android Tablet they would need to complete four interactions (take the device out of sleep mode, unlock the screen, open the menu tab and open the App). In order for participants to access the App on the iPad they would need to complete three interactions (take the device out of sleep mode, unlock the screen and open the App). Best practice guidelines state that when developing software no more than three steps should be required to complete a task (National Autistic Society, 2015). The use of an Android Tablet may cause frustration for children with ASD due to their symptomology and it runs the risk of decreasing motivation to engage with the App due to the extra step to engage. During an interview a stakeholder stated that access to the App is key for success- "not too many steps to get into the App, if it is too complicated they [children] won't get it".

The interviews also evidenced that all participants had been exposed to the use of iPads either at home or in school. To the knowledge of professionals none of the participants had been exposed to the use of Android Tablets within the school setting. In light of this, the familiarity of participants with iPads created a strong case for their implementation. The researcher considered all of the above points and decided, with consultation from professionals and parents, that iPads would be the most appropriate mobile device to implement. The researcher investigated, through the interviews, if any

participants had difficulty with fine motor skills or impaired vision with results showing that none of the participants had any known difficulties in these areas. These two aspects would have impacted upon the size of screen that the participants would require. In order to maximise portability a smaller device would be more suitable. As a result of the above the researcher purchased ten iPad mini's; one for each participant to utilise.

4.8 PhoneGap

4.8.0 Introduction

Prior to beginning this section it is important to note that the information provided and discussed is done so with the social care professional in mind. This section aims to provide the professional with an overview of the framework that was used to facilitate the development of the App while also providing an objective review for professionals going forward. This section begins by providing context to the social care professional by describing the framework and the features it can offer to a professional who is not computer science literate.

4.8.1 About PhoneGap

PhoneGap is an open source framework that facilitates the rapid production of cross-platform (supported by multiple operating systems) Mobile Apps (Giorgio, 2013). Open source is a term used in the area of computer science and describes software that is available to the public and can be modified or adapted by individuals with the aim of further development and improvement (Rouse, 2006). As stated by Lunny (2011), PhoneGap is 'at heart, a set of project templates for different mobile operating systems, allowing us to ignore the details of each SDK[11] and develop applications in a consistent fashion' (pg. 7). PhoneGap was released in January 2012 and has seen many iterations since then (Giorgio, 2013). The aim of PhoneGap is to package and release Apps as opposed to being a framework for creating Apps (Liang, 2012). This package allows for the creation of simple and affordable Mobile Apps while developing through languages

[11] Software development kit is a collection of software used for developing applications for a specific device or operating system (Christensson, 2010).

such as: HTML5, JavaScript and CSS. PhoneGap allows for these Apps to be packaged and used on native operating systems; Android, Windows and iOS (Adobe Systems, 2015). PhoneGap bridges the gap between web Apps and mobile Apps by using 'standards-based web technologies' (Adobe Systems, 2015); thus, PhoneGap Apps are compatible with evolving browsers (Laing, 2012).

4.8.2 Features of PhoneGap

PhoneGap provides the developer with access to some of the native features on mobile devices by creating plugins (Gifford, 2012). This was particularly important for the researcher for two reasons: access to some of these features was essential to meet the needs of end-users and the researcher did not hold the programming skills to natively programme these functions into the App. PhoneGap provides access to the following native features on Android and IOS operating systems:

- Accelerometer
- Camera
- Compass
- Contacts
- File
- Geo location
- Media
- Network Notification (Alert)
- Notification (Sound)
- Notification (Vibration)
- Storage

(Adobe Systems, 2015)

For the purpose of this research, the researcher utilised access to the camera and file plugin in order to facilitate the inclusion of the camera function within the App.

4.8.3 Limitations of PhoneGap

As with any framework, there are limitations to its use; some of which relate to native user interface (UI) components, design patterns and development tools (Dalmasso, et al., 2013). These limitations focus on the quality of user experience and how that experience is compromised through utilising a framework such as PhoneGap. Dalmasso et al. (2013), state that the quality of the user experience and the quality of the Apps produced through PhoneGap are ranked at medium to low. This categorisation is

based on comparison between hybrid (HTML5, CSS3, JavaScript and PhoneGap) and native[12] Apps. Paskevicius (2014), identifies a less obvious limitation to PhoneGap; it is open source only for the first. use. Thus, only the first App is free and a developer is then charged a monthly fee to avail of the service (Adobe Systems, 2015).One of the primary issues highlighted by Dalmasso et al. (2013), is the lack of support available to developers in overcoming the outlined limitations. An alternative to overcoming these limitations is to combine the use of several frameworks. Due to time and skill set restraints the researcher was unable to overcome this limitation and persevered with utilising PhoneGap as an independent tool. Even though there are limitations to the use of this framework there are also positives. PhoneGap provides developers with a tool to produces Apps in a simple and cost effective manner. PhoneGap's plug-in framework is also flexible enough so that new features can be added if required (Adobe Systems, 2015). The researcher, who is first and foremost a Social Care Professional, up skilled to learn programming languages that could be used in conjunction with PhoneGap to develop an App with children with ASD within the time and resource constraints of the project.

4.8.4 Justification for using PhoneGap rather than other available Cross Platform Tools

There are many software developers who evaluate and identify their top 5 Hybrid Mobile App Development Frameworks and present them in blogs and articles. This research has combined a number of those blogs/articles; thus, producing a list of the frameworks that are most commonly identified as being the most effective frameworks for Hybrid App development:

1. IONIC (Raj, 2014)
2. Intel XDK (Rudolph, 2014)
3. Appcelerator Titanium (Raj, 2014)
4. Sencha Touch (Raj, 2014)
5. Kendo UI (Raj, 2014)
6. PhoneGap (Rudolph, 2014)
7. jQuery and Backbone (Grisogono, 2014)
8. React (Grisogono, 2014)
9. The-M-Project (Gube, 2011)
10. Jo (Georgiou, 2015)
11. Xui.js (Georgiou, 2015)
12. EmbedJS (Georgiou, 2015)
13. Zepto.js (Georgiou, 2015)
14. DHTMLX Touch (Georgiou, 2015

[12] An App that is built specifically for one operating system e.g. Android

These frameworks can be categorised into two approaches: WebView App and Compiled Hybrid App (Rudolph, 2014). A WebView App allows for the use of HTML, CSSand JavaScript to develop the coding; which is then wrapped in a native App. PhoneGap is categorised as WebView App. A complied Hybrid App is used when an App is written in one coding language (e.g. C#) and complied into native code for a specific operating system (e.g. Android, iOS or Windows). This method is more restrictive for the developer and was not a viable option for the researcher to learn given the scope of the research project; thus, this is the rationale for this method being excluded from this research. The researcher was dependent upon the participants and stakeholders to decide on the operating system being used during the researcher and this was not decided upon until user requirements had been collected and analysed. Therefore, the WebView App was the viable option for this research. An analysis of the benefits of PhoneGap presented by Rudolph (2014), strengthens the researcher's case for implementing PhoneGap. The seven benefits are presented in table 11 below.

Table 11 Benefits of utilising PhoneGap

Benefit	**Description**
The developer can use existing web skills	the research is a social care professional who has up-skilled by learning HTML, CSS and JavaScript in order to develop this App.
One code base for multiple platforms	This was essential to the research as the type of mobile device that was used had not been clarified. This decision was made based on the needs of the children participating in the research.
Reduced development time and cost	The researcher had nineteen months to complete the research and had very limited funds available.
Uses Responsive Web Design	This was essential as the type of mobile device to be used was undecided.
Access to some device and operating system features	The triangulation of field and desk research identified user requirements for the App and some of the device features were required to be incorporated into the App e.g. camera. This benefit would allow for a quicker implementation of the feature into the App.
Advanced offline capabilities	This App was a part of daily living for the participants, thus, requiring online access would hinder the use of the App.
Increased visibility	The App can be distributed using App stores and search engines.

4.8.5 Evaluation of the implementation of PhoneGap

The researcher utilised PhoneGap in the later stages of the App development process. During the usability testing stages the researcher utilised web hosting so as to demonstrate and get feedback from the participants and stakeholders. The researcher continued to develop and test the App through the web hosting until version four of the App was complete. The ideology behind this was solely based on time restraints; it was much more time efficient to test new features through the online web hosting platform.

Once the researcher began engaging with PhoneGap Build, the limitations were immediately clear. The limitations included: loss of functionality, debugging the App and time. When the researcher deployed the App on the iPad for testing some of the features were corrupt even though they worked through web hosting. The researcher had to independently debug the App and upload several iterations of the same App (with different code solutions) before being successful. This 'simple and time effective' method for the production of hybrid Apps became time consuming and laborious.

The implementation of the camera feature appeared straightforward and had been completed through collaboration with IMaR within two days; however, deployment of the App again became an issue. The functionality of the final version of the App worked seamlessly when tested through an Android SDK; however, when uploaded to PhoneGap all functionality was again lost. Even the most basic features such as the sentence strip were corrupt. The researcher had to rebuild the App from scratch and test each feature independently by uploading it to PhoneGap before adding another one. The researcher successfully completed this process after three labour intensive days and then began attempting to rebuild the camera feature. This brought further obstacles; PhoneGap did not recognise its own plugins. The researcher attempted to overcome this by seeking documentation and researching online tutorials; however, all attempts were unsuccessful. The researcher decided to attempt an alternative approach; completing the development of the App through the PhoneGap Command Line Interface (CLI). The CLI is defined as 'a means of communication between a program and its user, based solely on textual input and output' (Dictionary, 2016, pg. 1). The researcher began investigating this method and utilised online tutorials to learn how to set up the SDK and to learn the commands required to be able to develop the App through PhoneGap. The utilisation of this method was a time

investment; however, once the researcher had identified and learned the skills necessary it became a much more effective approach. The researcher had learned the skills and set up the SDK within one day. The researcher was then able to test the App instantaneously while avoiding the cost associated with the online PhoneGap Build.

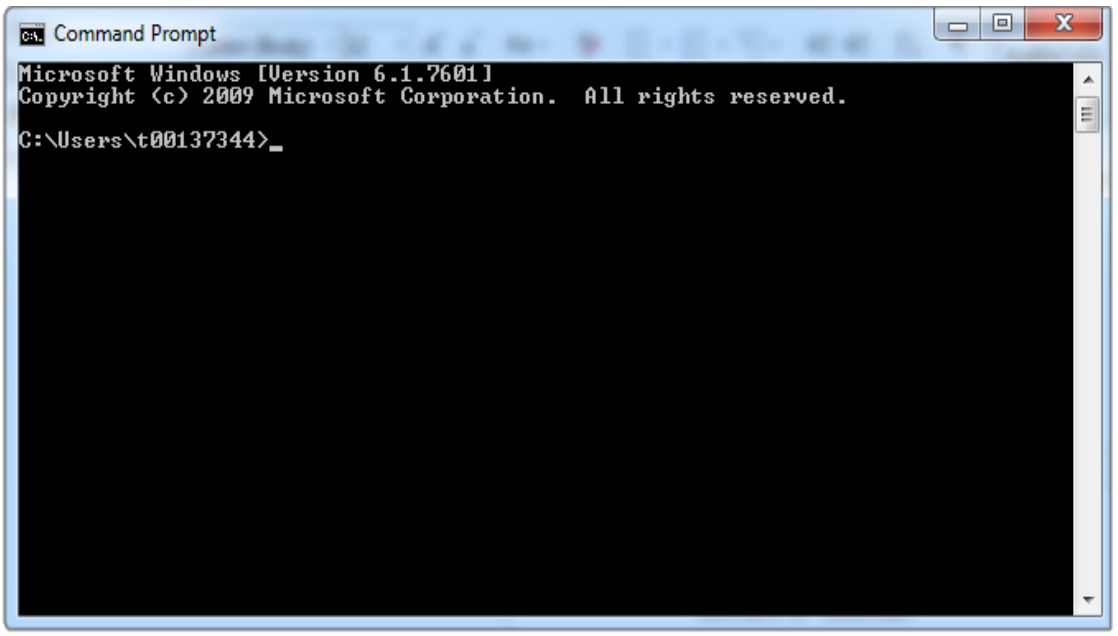


Figure 15 Example of a Command Line Interface

In conclusion, PhoneGap was a laborious and tedious method for the deployment of a hybrid App. PhoneGap did not provide what it advertised and this resulted in increased time frames and frustration for the development of the App. The CLI was a more effective tool and proved efficiency in producing an App; even though the set up required time investment. For a Social Care Practitioner, engaging in the process of PhoneGap is not recommended due to its inconsistencies in production of Apps and limitations in the area of de-bugging the App. From the evidence highlighted above an alternative method for deploying the App would be recommended in the future.

4.8 Plan of Implementation

Due to adherence to best practice guidelines the researcher did not have direct engagement with the children for the purpose of interventions (See ethical considerations) (Wakeel et al., 2015). As a result of the fact that the researcher was not paired with the children, interaction for implementation would risk effecting results. The most effective

people to implement the intervention were classroom teachers, special needs assistants and parents of participants (Wakeel et al., 2015). The involvement of stakeholders was also essential to ensure that a holistic approach to the intervention was being adopted. It was important for the success of the intervention that stakeholders be competent in engaging with the App. Prior to implementing the App with the children, staff and parents were offered a training session. The purpose of this training session was to explain each aspect of the App, explain their role and the role of the child and to allow them to get comfortable with the App by using it. The researcher gave stakeholders a letter of information for implementation (See Appendix JJ) along with the written plan of implementation (See Appendix X) in order to ensure consistency of implementation. This plan also provided staff with a step-by-step support system for times that the researcher was not on site (Appendix Z). The key aspects of P.E.C.S. were also explained to stakeholders so that the child would be engaging in functional communication i.e. the child would present their sentence to the stakeholder and engage in the exchange aspect of communication. The plan of implementation was developed based on the principles of discrete trial training. Discrete Trial Training (DTT) is a four step sequence focusing on positive learning. The four steps are 1. Instructional cue, 2. Child response, 3. Consequence (positive reinforcer) and 4. Pause. This process allows the child to effectively learn the skill presented to them.

Prior to implementation the researcher requested that stakeholders sign a contract of purpose (See Appendix KK). The purpose of this contract was to clearly outline the intended purpose of the iPad i.e. it was solely for the purpose of communication. The researcher requested that parents do not use it for any other purpose such as accessing the internet or downloading Apps. The intent behind this was that if children were accessing other Apps they would be confused as to the purpose of the iPad and subsequently would not be motivated to use the App to communicate (Johnson et al., 2006). There was the risk that the children would instead use the iPad for entertainment (King et al., 2014). Five parents attended the training session and agreed to sign the contract of purpose. The remaining five parents were contacted via the school on two other occasions offering them the opportunity to sign the contract; however, they did not avail of this. As a result of this, those who signed the contract of purpose were the only participants that took their iPad and App home. The remaining five participants only used the iPad and App while in school.

The plan of implementation was distributed to stakeholders the week before in order to allow them the opportunity to engage with the material. The researcher was available to staff full-time for the first week of implementation. The researcher was based on site and staff were given hands-on support when deploying the iPad and App to the children. The researcher distributed her contact information (email and phone) to parents and staff to offer support if required. The researcher began formal observations with the children the week after implementation.

In conclusion, this chapter highlights the use of A.R. and UCD for the purpose of developing a communication App for children with ASD and exploring its effectiveness. The methodological tools identified above contribute to the validity and reliability of the research conducted. The four iterations of the App brought about the development of version 5 of Onei that was truly user-centred. The use of the UPA User Experience framework ensured that the researcher was adhering to the principles of UCD. The extensive use of both methodologies was effective in ensuring research reliability and validity. The interdisciplinary approach to the development of the App brought about greater depth and breadth in the collection of user requirements.

4.10 Difficulties encountered and solutions when engaging in a multidisciplinary assistive technology project

As with any project or intervention there are difficulties and obstacles that require attention during its lifetime. This research was not an exception; the researcher encountered many obstacles that ranged from practical to personal. Some of the practical obstacles included: receiving buy-in, managing expectations, educating stakeholders and equipment.

Receiving buy-in from stakeholders was a vital task for the successful implementation of this intervention. The researcher attempted to overcome this obstacle by offering stakeholders an information session with the purpose of providing transparency around the aims and ethos of the research. The researcher was dependent upon stakeholders to enlist their trust upon her. This was a great ask of the stakeholders in particular when working with their children. There have been many controversies over interventions being advertised as evidenced-based; however, in fact, parents and

professionals have been provided with misleading information. Working with children with ASD brings about awareness in relation to their vulnerabilities; however, their parents and professionals are just as vulnerable and require protection in much the same manner.

As stated by Chien et al. (2015), parents of children with ASD report higher levels of stress and depression compared to parents of typically developing children; thus, increasing their vulnerability. The vulnerability among stakeholders was particularly evident in the case of the use of Miracle Mineral Supplement (MMS) in Ireland amongst parents of children with ASD. This scandal was exposed by Prime Time in an investigation conducted in 2015. MMS is a bleach substance which was being promoted as a cure for autism, cancer, HIV and other conditions (Leogue, 2015). This was a clear exploitation and abuse of power from those involved in this scandal and compromised the lives of many people with ASD in the experimental process. As a result of these scandals, it is unrealistic to expect stakeholders to agree to an intervention without receiving extensive transparent information. It was the responsibility of the researcher to provide this and the information session was key to receiving approval from stakeholders. The researcher also provided her contact information if stakeholders had any questions or concerns at any time. These steps were the foundation to building an effective and successful relationship and partnership with stakeholders. However, it was also the responsibility of the researcher to ensure that expectations of the results of the intervention were not unrealistic.

The management of expectations among stakeholders was an issue that was at the forefront of the researchers mind from the beginning to the end of the research. The researcher was vigilant not to make promises in the area of expected outcomes. The researcher continuously reminded stakeholders that the purpose of the researcher was to prove a concept and measure effects, if any, for the children. Again, the vulnerability of stakeholders was evident here with some stakeholders having higher expectations for results than those presented by the researcher. During the summer months when the researcher did not have direct face-to-face contact with stakeholders the expectations of outcomes appeared to increase. The researcher then had to reiterate the purpose of the research; which initially caused frustration for the stakeholder, but upon reflection they realised that the researcher was conducting the intervention as outlined at the information session. One particular stakeholder may have engaged in reading literature (particularly news articles) over the summer months that sensationalised the potential benefits to this

type of intervention. The launching of a new software for ASD in Ireland holds strong correlation of increased expectations amongst the stakeholders involved in this research. TippyTalk was launched in June 2015 with extensive media coverage; thus, creating an air of enthusiasm within the ASD community. The metaphor used within the TippyTalk system is similar to P.E.C.S.; thus, holds similarities to this research. The management of expectations within this research was a continuous task that required sensitivity, empathy and education.

The education of stakeholders was a task that was evident throughout the research. The researcher first had to provide a literature review, in the form of a presentation, on the use of these types of interventions along with the potential benefits. Some of the stakeholders would not be confident in the area of technology; thus, held a certain level of apprehension prior to receiving knowledge in the area. The researcher was also required to provide support and training to stakeholders in the implementation of the intervention (See plan of implementation for more detail).

The final obstacle for the researcher prior to implementation of that App was that of obtaining an iPad for each child. The researcher, with the approval from supervisors and the research site, began a fundraising campaign. The researcher was fortunate enough to receive funds from fifteen people and/or organisations to purchase an iPad, a protective cover and a ChatBag for each child. Without these sponsors the researcher may not have been able to provide each child with a device; thus, limiting the amount of time each child would have been exposed to the App.

Even though the researcher was faced with some practical obstacles; the solutions to these were based on transparency, communication, relationships and partnerships. Overcoming these obstacles were not as straightforward as someone may think; but they were feasible. The researcher also encountered some personal difficulties along this journey. The personal difficulties that arose were in relation to; equipment and the journey to transitioning from a Social Care Professional to an interdisciplinary professional.

For the purpose of developing an iOS App the researcher required a Mac computer. iOS operate on a closed network which means that only iOS devices are compatible to each other and when developing for iOS; iOS equipment is a necessity. The researcher overcame this obstacle by borrowing a Mac Book Pro laptop for the duration of the design phase.

However, this is a valid consideration for any practitioner engaging in this process as the cost of an Apple laptop is approximately €1,500.00.

The transition from a Social Care Professional to an interdisciplinary professional was one that involved steep learning curves. The task of learning programming languages was insightful for the researcher and provided an understanding of a discipline that she was not familiar with prior to this. The researcher also developed the ability to communicate with programmers while using their jargon and terminology as a result of learning programming languages. However, as for the researcher being the independent developer of the App; it is not recommended. This process was not only challenging and laborious but it was time consuming. In hindsight, it would have been much more productive and effective for the researcher to engage in CPD classes, collect user requirements, conduct U.T. and engage in the journey of UCD, but, enlist a qualified and experienced App developer to develop the logistics of the App.

The engagement in the CPD and UCD processes were key learning experiences that enriched the procedures and outcomes of the research and are a recommended step for future Social Care Practitioners to engage with. However, for the future enhancement of technology and App development it is the researcher's recommendation to enlist an App developer. A multi-disciplinary team is essential for designing technology with children with ASD; thus, both disciplines hold valuable expertise and positions within the process. Social Care Professionals provide web and App developers with the knowledge they require to develop effectively for this population. As stated by Pagni Britto (2015), 'researchers are needed to investigate which design features are critical to provide therapeutic and pedagogical effect for people with ASD in order to understand the potential impact of technology in their change of behaviour and provide a formalisation of this knowledge for web developers and designers' (pg. 4).

In conclusion, the researcher overcame many obstacles and barriers throughout the duration of this research. Some of the physical barriers, such as, borrowing a Mac or having difficulties with programming languages, were much easier to overcome compared to others. For example, the management of expectations is a barrier that holds potential to cause great damage to partnerships but also to the findings of the research. The researcher needed to be consistently aware of this barrier and address it at every stage.

The researcher did not want to cause any undue stress or upset to stakeholders or participants; thus, empathy, active listening and sensitivity were required throughout.

4.11 Chapter Summary

In conclusion, this chapter has provided an extensive overview of the UCD process engaged in for the purpose of this research. The adaptations that were required in order to develop a framework that was multi-disciplinary were discussed in detail. The twenty steps that were required provided this research with the opportunity to develop an App that was truly user-centred. As a result of incorporating these adaptations the collaboration between the social sciences and computer sciences became effective and transparent. The researcher created a tool that was implemented efficiently and effectively. As previously outlined, the implementation plan was crucial to the success of the intervention. Thus, this highlighted the important role that stakeholders play in the lives of children with ASD. This chapter provided an overview of the iterative process of the development of the App with the presentation of features for each version of the prototype. As a result of engaging in this process, the final features of the App were incorporated based on evidence and user needs. Each feature was discussed in detail along with a justification for its inclusion. The final section of the chapter discusses the difficulties that were encountered by the researcher and this focused on both personal and practical issues. However, these issues were overcome by the researcher throughout the duration of the research. The previous two chapters have clearly identified and explained the methodologies and tools utilised to develop a communication App for children with ASD. Chapter 5 presents the findings and results of the tools utilised within this research.

Chapter 5: Results and Findings

5.0 Results and Findings Chapter Introduction

The results generated from this research primarily took a formative testing approach due to the methodologies being utilised. As evidenced in chapter 3 and 4, A.R. and UCD hold user and stakeholder involvement at the core along with engaging in iterative processes to ensure end user needs are being met. The summative testing aspect of the data collection phase occurred in phase four of the UCD framework. The results of the research are presented in chronological order; from formative to summative testing. The summative testing was very important to this research as its aim is to evaluate an intervention; thus, in order to answer the research questions set out in chapter one summative testing was essential.

Summative testing is 'used to evaluate student learning, skill acquisition and academic achievement at the conclusion of a defined instructional period- typically at the end of a project, unit, course, semester, program or school year' (Great Schools Partnership, 2013, pg.1). There are three main aims of summative testing; which include: 1) evaluation of student learning and whether or not they have achieved the aims and objectives of the intervention (Eberly Center, 2016); 2) evaluation of the effectiveness of an intervention (Garrison and Ehringhaus, 2016); and 3) the development of scores for each child which can be indicative of the quality of programme and appropriate placement of the child in that intervention (Desai, 2016).

The results of the summative testing were generated through the utilisation of a mixed methods approach. As previously stated, the results are presented in chronological order as utilised during the UCD process. Figure 5 identifies the tools utilised at each of the four stages and results are presented accordingly.

Section 5.1 discussed the methods used in phase one and the results received from those tools; interviews, participant profiles and observations. Interviews and participant profiles were forms of formative testing while observations occurred in both the formative and summative testing. The results provide evidence to the current use of the metaphor and mobile devices along with acquiring user requirements for the development of prototypes.

Section 5.2 presents the results gathered from tools utilised in phase two and three and each tool is discussed independently. The tools that were utilised throughout this phase were; a focus group, usability testing with participants and online usability testing with stakeholders. All of these tools were aspects of formative testing. The aspect of summative testing took place in section 5.3.

Section 5.3 presents the results gathered from phase four of the UCD process with the utilisation of the Autism Treatment Evaluation Checklist, the mid-term feedback questionnaire and the final evaluation questionnaire. This section presents both formative and summative testing methods with the triangulation of all methods occurring in section 5.4.

Section 5.4 presents the data with respect to each participant, treating and presenting the data as a unique case. As children with ASD are a heterogeneous population, comparing participant results against each other would be unjust and potentially present findings that were inaccurate. Each child is assessed against themselves in order to provide consistency and validity as each child is affected by ASD in a different way. This section also provides the triangulation of results for each child with the aim of answering the research questions presented in chapter one.

5.1 Phase one- Analysis

This section presents the use of interviews, the participant profile and observations for the purpose of data collection in the area of user requirements. The use of interviews allowed the researcher to gain insight into the current use of P.E.C.S. and mobile devices and Apps amongst participants.

5.1.1 Interviews

The interviews occurred in the early stages of the research with the purpose of formative testing. Interview results were utilised to identify user requirements for the App. There were three sections to the interview structure with the focus being on 1) the use of P.E.C.S., 2) the use of mobile devices and 3) the use of Apps. The results of these interviews are presented in this format with the use of P.E.C.S. being presented first.

Table 12 Results from section one of stakeholder interview

Question	**Response**
How often do the children currently use PECS?	"daily"; "mostly around food"; "it depends really"
Are you aware if the children only use PECS when in school or do they use it for everyday living?	"I think each of the parents said that they at least tried it at home at varying stages. I'm not sure how consistent it has been."; "[participant] uses it at home the whole time, she uses it a lot at home. [participant] uses it a good bit at home as well. [participant] I don't think so no."; "they only use it in school"; "at home, not as much in the community".
In your experience have you identified any negative aspects to PECS?	"They didn't seem to understand the symbols"; "it's hard to leave pictures in there that they cannot access all of the time….I have to limit the vocabulary in the book"; "pieces falling out of the folder or not having a picture when you need it"; "would speech develop".
What, if any, aspect would you like to change in the current PECS system?	"The standardised symbols are a bit abstract"; "the messiness of the folder"; "to make it easier in producing pictures".

The results generated from these interviews highlight that P.E.C.S. was not being used consistently and a holistic approach to the intervention was not taking place. This was addressed in the next two sections of the interview.

Table 13 results from section two of stakeholder interview

Question	**Response**
Do the children currently use the iPad in school/home?	"We haven't been using the iPad at all up to now"; "yes".
If so, do they request permission to access the iPad or is it freely available to them?	"Both- there are times when she knows it's available, other times she will go to her P.E.C.S. book and get the picture of the iPad".
Would you foresee any difficulty using a smaller device e.g. iPad mini vs ipad2 due to fine motor skills with the children?	"No- [participant] has the ability to use iPhone 3"; "I'm not sure, not with two of them but maybe one of them. I'm not sure how you would manage it really. They would be grand with 7 inch"; "no"
How often do they use the iPad?	"A few sessions a week"; "daily"; "they would all have a turn every second day".

What purpose/s do they use it for?	"academic- English, letter sounds"; "both- educational puzzles, tracing words, etc. have all helped with her fine motor skills. Instatube- restricts access to youtube (parents control the content)"; "both academic and social".

This section of the interview highlights the level of exposure that children receive in relation to mobile devices and App. There was a trend of restricted access with stakeholders controlling when participants accessed the devices and what Apps they could access. The final section of the interviews took a particular focus on the Apps and the results are presented below with an additional stakeholder comments presented in Appendix LL.

Table 14 results from section three of stakeholder interview

Question	**Response**
Which Apps in particular do the children use on the iPad?	"starfall, ABC, puzzles, there are loads"; "instatube, the five monkeys, playschool, she learned a lot of social skills from these"; "phonics, maths for higher levels, for lower levels we are trying to introduce Proloquo2Go".
Do any of the children currently use a specific communication App/s? *If so, what App/s?*	"no. The problem was that the Apps were more educational so the problem was getting her to use the specific iPad for communication only"; "The Proloquo2Go or Grace. They are there but they are not being used. The children who need them do not have iPads. That's the issue".
If they already use a communication app	"The huge downfall at the moment would be
what are the benefits and downfalls of using these Apps?	that the pictures they are using now are not there, like the P.E.C.S. symbols would work right through from school to home. Consistency of pictures. Symbols and pictures are not there already they need to be preloaded";
Are any of the children currently using or have the ability to use the camera function to take their own pictures using an iPad?	"no not able at the moment"; "yes, she likes taking different photos"; "yes, have ability and are using"

The results gathered from this section identify that participants were located on a spectrum and implementing the user-requirements was essential for meeting the needs of the participants when developing the App.

In conclusion, as evidenced in these results triangulation occurred between data collected during the research project and that of the literature. The interviews were the foundation for the development and identification of user requirements and were a key

component in the development of low fidelity prototypes. As a result of conducting interviews the researcher developed a participant profile with the aim of receiving further information on each child and their behaviours along with collecting further user requirements.

5.1.2 Participant Profile

Participant profiles were developed by the researcher with the purpose of receiving insight into the personality of each child and also the collection of preliminary user requirements (See Appendix MM). The researcher was the only person with access to these profiles due to the sensitive nature of the information being provided. However, the completion of these profiles evidenced consistent themes amongst participants. The table below presents the results generated from the participant profiles.

Table 15 Themes that emerged from the completion of the participant profiles

Theme	**Result**
Communication	P.E.C.S. was being utilised by participants; however, consistency across settings was an issue.
Social Inclusion	Low levels amongst participants.
Attention Span	Short- easily distracted by environmental factors.
Behaviours that Challenge	Majority engaged in behaviours; however, each type of behaviour was different in its manifestation.
Independence	Minority of children were independently communicating through P.E.C.S.
Sensory Processing	High noise levels were a difficulty for some participants. Stakeholders unsure if participants were sensitive to high colour contrasts.

The participant profiles played a key role for the implementation of following data collection tools; particularly, for the observations. The profiles provided the researcher with background information on the children and highlighted behaviours that were regular for them; thus, aiding the researcher in collecting more accurate information during observations.

5.1.3 Observations

The use of observations occurred in both the formative and summative testing phases. As outlined in section 3.4.3, the purpose of observations was to collect user

requirements and also to evaluate the progress being made by participants. The researcher conducted informal observations during the development phases of the App. The results of these observations were parallel with those of the formal observations during the implementation phase. When evaluating the progress made by participants it was key to assess them against themselves as with the ATEC results. Thus, the data collected during observations is presented in greater detail on an individual basis in section 5.4. However, upon analysis of the results of the observations there were six key themes evident throughout. The six key themes were: communication, social interaction/inclusion, independence, behaviour that challenges, attention span and motivation to engage with the App. The development of these themes are consistent with the literature presented particularly in section 2.2.5 which focuses on the symptomology of ASD. The characteristics of ASD evident amongst participants were essential for the development of the features within the App. For example, sensory stimulation was a key attribute among participants; thus, it was incorporated into the development of the App. The observations played a significant role in the triangulation of the quantitative data that was collected. The observations were unique to each participant and are discussed accordingly in section 5.4.

In summary, the use of these three tools proved effective for the identification of preliminary user requirements. These were then utilised to develop both low and high fidelity prototypes that were tested firstly with stakeholders and then with participants. The results of these sessions are presented in the following section.

5.2 Phase two and three- Design and Implementation

Phase two and three are presented concurrently due to the fact that UCD is an iterative process and the tools utilised within both of these phases were the same. Throughout these phases the researcher utilised a focus group, usability testing with participants and an online usability testing session with stakeholders. The results are presented independently below beginning with the focus group.

5.2.1 Focus Group

As previously outlined in section 3.4.2, a focus group is a small group discussion that is facilitated by the researcher and focuses on a particular topic (Seale, 2012). The use of a

focus group was essential for the formative testing of the App. The focus group took a multi-disciplinary approach and consisted of parents, classroom teachers and SLT's. Participants were introduced to the U.T. session where they first engaged with a user scenario (See Appendix N). The participants independently engaged in this task and provided individual feedback to the group. The results evidence that even though a multi- disciplinary group was engaging in this task they each drew up similar responses during this task. The results of this task are presented in the table below.

Table 16 User Scenario Stakeholder results

User Scenario	**Themes**
Tasks in School	1. P.E.C.S. is time consuming. Stakeholders utilise Google to access images- time consuming (searching, printing, laminating, etc.). Need something to create pictures quickly- something versatile. 2. Progression- adding new pictures. 3. Restriction of vocabulary when using paper P.E.C.S.
	4. Loosing pictures is very common. In the school pictures are placed where children can't reach them. 5. Children progress at different paces to the different stages of P.E.C.S. 6. A parent uses P.E.C.S. as much as they can. 7. One participant won't use P.E.C.S. at home. 8. Children like iPads, iPods, etc. they are cool- it puts them in control. 9. Provides consistency in the communication tool being utilised. 10. Functional communication. 11. Progressed with support of picture. 12. Consistency in pictures being used e.g. home vs school. 13. Consistent voice in App would be good. 14. Good for non-verbal kids- visual backup. 15. Great foundation for language using pictures
Tasks at Home	1. Possibility of deleting the App could cause difficulty for participants and stakeholders- restrict the App- parent lock. 2. Worried about child requesting an item they can't have right now. 3. Works well for transition. 4. Camera option- must be careful they can't take pictures of things they can't have. 5. Visual schedule. 6. Modelling sentences.

Tasks in the Community	1. iPad is more socially acceptable. 2. Opportunity to communicate in new areas. 3. Symbol/picture with word underneath. 4. Some P.E.C.S. pictures are confusing. 5. The need to follow P.E.C.S. methodology.

As presented in the above table, the key requirements that surfaced as a result of the user scenarios were: consistency in symbol sets; the limitations to P.E.C.S.; and the iPad as a socially acceptable tool that the children show interest in using. Two key observations from this data collection phase were:

1. Stakeholders were apprehensive about giving complete access to vocabulary and concerned about saying no to children and

2. Control over the camera feature.

These observations are discussed in greater detail in section 6.3. The stakeholders then evaluated the first high fidelity prototype while being allocated to a smaller multi-disciplinary group within the focus group. The researcher requested that the groups evaluate the App in terms of its features (See Appendix O). The emerging themes of the results generated from this task are outlined in the table below.

Table 17 Focus group App prototype evaluation results

Feature	**Comment**
Swiping	Scanning left to right would be better as it would encourage pre-literacy scamming of items.
Colour scheme	Orange better, clear background is perfect
Categorisation	Option for word within multiple categories
Verbs/nouns	Colour coding- colourful semantics- supporting the development of sentence structure.
symbols	Add written label, more space between images, “I want” symbol at the top of each page, master page for all symbol directory, drag and drop feature to facilitate duplication of symbols across categories, option for hiding pictures (icommunicate), generic items on each page to help children, picture template (Boardmaker), adaptable (icommunicate)

In conclusion, the use of focus groups was imperative for formative testing which informed the development of several versions of the App. This was an effective tool for its purpose; however, it required the use of other tools in order to collect user requirements of greater depth. One of the other methods utilised to facilitate this was usability testing with participants and stakeholders.

5.2.2 Usability Testing with parents, professionals and children with ASD.

The concept of usability testing (U.T.) was discussed in section 4.6; however, this section focuses on the data collected from these sessions. U.T. was conducted with both children with ASD and stakeholders. As previously outlined, U.T. sessions occurred in the form of a focus group, an online usability testing session and group usability testing session. As presented in section 6.4.2, the first iteration of U.T. was conducted in the form of a focus group. Following on from this, U.T. sessions took place with participants and through an online U.T. session with stakeholders over the summer period.

Following the results collected in the focus group and the development of another iteration of the App, participants became involved in U.T. (See section 4.6). The researcher developed a U.T. checklist for the purpose of data collection (See Appendix II). This checklist focused on three key areas: effectiveness, efficiency and engaging. The development of these were underpinned by the final usability goals of the App. The results of the two U.T. sessions identified features that were proving difficult for the participants (swiping feature, colour scheme) and features that were effective for participants (use of categories, sentence structure). The development of the iterations of the App are presented and discussed in detail in section 4.5. After engaging in these two U.T. sessions with participants, stakeholders were again involved in another iteration of the App through the use of online U.T.

The online U.T. session was conducted with parents and professionals who volunteered their time over the summer period. Stakeholders engaged in one U.T. session which took place mid-July 2015. The evaluation of this prototype (version 4) was presented in the form of a questionnaire. The questionnaire posed ten closed questions and one open questions (See Appendix K). The results of this U.T. session are presented in the tables overleaf.

Table 18 Question one of U.T. session with stakeholders

Question 1	**a) Visually over-stimulating- I would prefer a lower contrast**	**b) Easy on the eye and is engaging**	**c) Distracting for me to look at the items displayed on the page**	**d) Of low contrast and allows me to concentrate on my sentence structure**	**Comments**
The colours of the background and sentence strip are:	-	3	-	2	Very user friendly and easy to focus on sentence structure. The pastel colours work well as don't distract from the pictures.

Table 19 Question two of U.T. session with stakeholders

Question 2	**a) Distracting**	**b) Reinforcing for me and encourages me to attempt verbalisation of words**	**c) Cool because its familiar (local accent- voice compared to synthesised voice)**	**Comments**
The voice output in the App is	-	2	2	Very clear. Clear & concise voice. Possible option: When the images have been selected and forms a sentence it would be beneficial if when the child/adult taps the sentence strip the full sentence is verbalised in full.

Table 20 Question three of U.T. session with stakeholders

Question 3	**a) Right for me**	**b) Very small**	**c) Just a little too small to see them properly**	**d) A little too big**	**e) Other**	**Comments**
The size of the symbols within the App are	3	-	-	-	-	

Table 21 Question four to seven of U.T. session with stakeholders

Questions 4-7	**Yes/True**	**No/False**	**Comments**
The layout of the categories are clear and simple	2	1	Possibly spread the images out more. Less chance of decreased fine motor skills/ visual difficulties affecting choice of image.
The pictures used within the categories are appropriate and clear	3		They are appropriate but positioning on template needs to altered i.e. verbs/ phrases should be in the left column of the page as follows: 'I want' I eat' Toilet could be placed in one of the corners on the right hand side. Background colour looks good but the coloured outline of each picture could be thicker and darker to make it more obvious e.g. the image 'drink' mergers with the overall background of the page making it more difficult to differentiate and it gets lost in the background.

It was difficult to find a picture I wanted which was located in the categories	1	2	See above re: keeping verbs and sign for toilet in the same location throughout. Grouping images based on meals i.e. snacks/dinner/drinks/breakfast. This may not be an issue for those children with a learning difficult as they will not have a lot of options on each page.
The App is effective in providing me with the ability to find a picture of my choice and add it to the sentence strip	3		

Table 22 Question eight of U.T. session with stakeholders

Question 8	**a) Difficult to figure out**	**b) Effective in its purpose**	**c) Difficult to use**	**d) Easy to use**	**e) I would prefer another option to delete the picture**	**Comments**
The function of the X button on the sentence strip was:	-	1	-	2	1	It may be beneficial to have the 'x' symbol as a separate button within the sentence strip

Table 23 Question nine of U.T. session with stakeholders

Question 9	**Yes**	**No**	**Comments**
I was able to delete a picture from the sentence strip within two attempts of clicking the X button	3	-	All pictures disappeared when clicking X so had to start again constructing sentence strip. Would a 'Back' facility be easy to add? This would be useful if wanting to remove an incorrect picture that was added.

Table 24 Question ten of U.T. session with stakeholders

Question 10	**a) User-friendly and easy to use**	**b) Difficult to understand its purpose**	**c) Effective in discriminating sentence structure from communication**	**d) I would prefer another option to view the sentence strip**	**Comments**
The expand button in the sentence strip was	2	-	1	-	(One unanswered) When you tap the sentence strip for full verbalising of sentence it could be useful if it automatically to a bigger screen with bigger simples to clarify and reinforce requests for the child. Otherwise, the purpose is lost. It may be beneficial to have the 'x' symbol as a separate button within the sentence strip

A final version of the App was completed post the online U.T. session and was implemented with participants. Upon implementation of the App with participants the researcher conducted a third U.T. session which included all participants. As can be seen in phase 4 (deployment) in the UCD framework, conducting U.T. as early as possible within the phase is essential for the collection of further user requirements so as to continue the iterative process of UCD. The final U.T. checklist was derived on foot of the five E's: effective, efficient, engaging, error tolerant and easy to learn (See Appendix NN). These were again developed in conjunction with the final usability goals for the App. The results of this U.T. session is presented in the table overleaf.

Table 25 Final usability testing checklist with participants (deployment phase of UCD framework)

Tasks to be observed and measured	**Part. 1**	**P. 2**	**P. 3**	**P. 4**	**P. 5**	**P. 6**	**P. 7**	**P. 8**	**P. 9**	**P. 10**
Locate a picture, add it to the sentence strip and present it to the communicative partner. Effective	X	✓	✓	✓	✓	✓	✓	✓	✓	✓
Display the sentence strip full screen by tapping the expand button prior to presenting it to the communicative partner. Effective	X	✓	✓	X	✓	✓	✓	✓	✓	✓
Delete an error symbol within two attempts of tapping the cancel button. Effective	X	✓	✓	X	✓	✓	✓	✓	✓	✓
Access their desired vocabulary in three clicks or less and within 4 seconds. Efficient	X	✓	✓	X	✓	✓	✓	✓	✓	✓
Navigate to their desired category in under 5 seconds. Efficient	X	✓	✓	X	✓	✓	✓	✓	✓	✓
Build a sentence of their choice and present it to the communicative partner in under 10 seconds (for level 4)/ 5 seconds (levels 1 to 3). Efficient	X	✓	✓	X	✓	✓	✓	✓	✓	✓
Clear the sentence strip in under 3 seconds. Efficient	X	✓	✓	X	✓	✓	✓	✓	✓	✓
Can undo an error in 5 seconds. Efficient	X	✓	✓	X	✓	✓	✓	✓	✓	✓
Focuses on the vocabulary as opposed to the background colour of the interface.	X	✓	✓	✓	✓	✓	✓	✓	✓	✓
Are users attracted to the interface? Engaging	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Are users engaging with the App? Engaging	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Buttons are distinctive and the function of each button is clear. Error Tolerant	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
The language used is simple and appropriate /familiar to the user. Error	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Any errors occurring within the App? Error Tolerant	X	X	X	X	X	X	X	X	X	X
Each child is given a demonstration of the App by a staff member familiar to them.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Independent use of the camera feature. Easy to Learn	X	X	X	X	X	X	X	X	✓	✓

The results of this U.T. session highlight that the majority of participants had the ability to navigate the basic functionality of the App. With the support of the written implementation plan that was distributed to stakeholders, it was the aim that the participants would be taught how to navigate the full functionality of the App independently during the course of the intervention. The final questionnaires distributed to stakeholders addressed these topics and the results highlighted that there was a 64.28% effectiveness rate amongst participants. As can be seen in the table above none of the participants could utilise the camera feature during the U.T. session; however, upon completion of the intervention stakeholders reported that 35.71% were utilising the camera feature independently and a further 57.14% showed potential to learn how to use it independently in the future. Even though participants could not successfully navigate the full functionality of the App during the U.T. session, for the majority it did not hinder their potential to learn, with time, how to navigate it successfully. Therefore, the value of the inclusion of stakeholders not only in the development but also the implementation of the intervention is key to the success of the participant. This theory was also evident throughout the deployment phase of the intervention.

5.3 Phase four- Deployment

The tools implemented within this phase focused primarily on the summative testing of the intervention. In order to facilitate this the researcher used the Autism Treatment Evaluation Checklist (ATEC), observations and questionnaires. This section presents the results and findings that were gathered as a result of utilising these tools. These tools were utilised for the purpose of both formative and summative testing; however, summative testing was the dominant theme in order to identify the effectiveness of the intervention. The results of the observations have been discussed (see section 5.1.3), due to the consistency in results gathered from both the informal and formal observations. The ATEC was the primary quantitative tool utilised to measure progress within each child.

5.3.1 Autism Treatment Evaluation Checklist (ATEC)

The ATEC was utilised by the researcher during fortnightly observations with the children. A baseline and four subsequent assessments were carried out with each child.

The table overleaf presents the results of the checklist for each child. Participants are coded using numbers in order to abide by ethical guidelines. As can be seen in the table below, participation in the research by participants 5 and 6 was suspended after approx. seven weeks.

The decision to suspend participation for these children was not taken lightly; however, given their personal circumstances at the time it would have been unethical for the researcher to continue with observations. The researcher did not remove the devices from the children; however, it was decided that the researcher would no longer monitor the progress of the children. This decision was taken in order to uphold the ethos of care, welfare and safety not only for participants but also for the researcher. The researcher liaised with the classroom teacher and the Principal of the school in finalising this decision (See Appendix OO). Participant 3 was absent for the final assessment; the researcher attempted on several occasions to complete assessment four; however, the participant remained absent from school. The remaining seven participants completed the four assessments; with the results presented overleaf.

Table 26 participant results from the Autism Treatment Evaluation Checklist (ATEC) [the lower the score the better the result, max score of 180]

	baseline	**Assessment 1 (12/10/2015 or 19/10/2015)**	**Assessment 2 (02/11/2015 or 09/11/2015)**	**Assessment 3 (16/11/2015 or 23/11/2015)**	**Assessment 4 (30/11/2015 or 07/12/2015)**	**Average Score (Assessment 1-4)**	**Result (absolute)**	**Result (% relevant to baseline)**
Participant 1	**88**	85	72	71	82	**77.5**	-10.5	-11.93
Participant 2	**55**	38	38	30	34	**35**	-20	-36.36
Participant 3	**29**	24	19	16	absent	**19.6**	-9.33	-32.17
Participant 4	**107**	69	66	49	55	**59.75**	-47.25	-44.16
Participant 5	**85**	77	47	suspended	suspended	**62**	-23	-27.06
Participant 6	**80**	67	51	suspended	suspended	**59**	-21	-26.25
Participant 7	**68**	57	51	43	56	**51.25**	-16.75	-24.63
Participant 8	**42**	39	45	26	20	**32.5**	-9.5	-22.62
Participant 9	**44**	26	18	26	13	**20.75**	-23.25	-52.84
Participant 10	**69**	64	40	31	40	**43.75**	-25.25	-36.59

The above scores were generated online by the Autism Research Institutes software package and the researcher was provided with a report for each participant each time the checklist was completed. As stated by the Autism Research Institute (2016), the lower the score the less difficulties the child presents with. Scores are distributed across four sections with a total range of 180. The table above clearly highlights through the baseline scores that participants' scored across a broad spectrum (lowest score was 29; highest was 107).

It is clear from the table above that this intervention was effective for all participants. Even though participants 5 and 6 were suspended after two assessments a decline in their scores indicated the potential benefits that this intervention could have brought if they had been able to participate until the end. The results show that the average score decrease amongst participants was 20.583. This is particularly relevant to the symptomology of ASD due to the fact that the four sections in the ATEC address the symptomology; thus, participants received improvements in the areas of communication, social and behavioural skills.

During the researcher's systematic review of the literature, research is yet to utilise this tool when assessing the effectiveness of communication Apps and mobile devices on children with ASD. Available research focuses on the qualitative responses of stakeholders on perceived improvements as opposed to collecting quantifiable data. However, Magiati and Howlin (2003), utilised the ATEC when evaluating the effectiveness of P.E.C.S. with children with ASD. The ATEC proved an effective tool to measure progress within this study; thus, due to the use of the same metaphor the researcher was justified in utilising this tool.

When evaluating the results and putting them in context, the figures evidence that the lowest decreases in scores were 9.5 and 9.33; however, these participants were already the lowest scoring in the baseline assessment. Therefore, in numerical terms the intervention appears less effective when in fact the child's baseline score requires acknowledgement. The presentation of percentage results aims to provide context to the overall results received with respect to children's baseline scores. The percentages highlight that there is a consistent trend in relation to effectiveness of the intervention. The results again appeared on a spectrum ranging from 11.93% to 52.84%. The lowest absolute scores that were received (9.5 and 9.33) fall well within

that spectrum presenting a decrease of 22.62% and 32.17% respectively. Therefore, this highlights that even though absolute scores appear small when analysed in greater depth and breadth the true impact of the intervention can be visualised. The use of multiple tools in data collection is important so as to triangulate the results from utilising this tool. In order to triangulate these results, the researcher sought feedback from stakeholders through the use of questionnaires.

5.3.2 Questionnaire Data

The researcher received three out of a potential seventeen stakeholder responses to the first questionnaire (mid-October). The results of the questionnaire demonstrated that there were recommendations being made to improve the functionality of the App; however, these were beyond the scope of the researchers skill set and the timeframe given for this project. Two of the requests focused on the inclusion of voice output for personalised symbols taken through the camera feature within the App. This was a feature that was beyond the scope of the project; therefore, it could not be facilitated for implementation but is discussed in chapter 6.

One of the requests focused on instantaneously meeting the needs of one of the end-users. The stakeholder had identified that the end-user used a limited amount of images and as a result of having a short attention span, would disengage from the App by the time the stakeholder had sourced the image required. A second issue that was highlighted by the stakeholder was the size of the images; stating in the questionnaire that if the images were bigger it could potentially increase accessibility for the participant. The researcher had allocated the week of mid-term within the research work plan for modifications to the App that were identified by either the participants or the stakeholders.

The two issues highlighted above were elements that the researcher had the skills and time to modify. However, the researcher was dependent upon the stakeholder to provide the customised images required for the participant. Prior to mid-term break the stakeholder agreed to email the images to the researcher so they could be incorporated into the App in order to have access to the voice output feature. The researcher developed a version of the App that had accounted for a

limited amount of personalised images and increased size of the images. The researcher reminded the stakeholder on several occasions over the following weeks that the images were required in order to proceed; however, they were not received until week seven. As a result of the fact that there were only three weeks left in the intervention the modified version of the App could not be implemented. If the researcher implemented this version of the App at this late stage of the data collection phase it would have produced results that were inconsistent. The true results of the intervention would not be able to be assessed as the testing time would not be sufficient. The decision was made to continue with the intervention as in the first seven weeks and continue exposing the participant to the iPad and the App.

Summative testing through questionnaires occurred in the final stages of the data collection phase. Parents, classroom teachers, Special Needs Assistants and SLT's were requested to complete a questionnaire to evaluate the effectiveness of the intervention. The researcher received five out of five parent questionnaires, nine out of ten staff questionnaires and zero out of two SLT questionnaires. The researcher contacted the SLT's through email with the request to complete the questionnaires; however, due to a lack of contact with the children they felt it would be inappropriate to evaluate the effectiveness of the intervention (See Appendix PP). The results of the questionnaire are presented in five sections as per the design of the questionnaire. The aim of the questionnaire was to evaluate the effectiveness of the intervention in terms of a child's communication skills; social inclusion; independence; attention span and behaviours that challenge. The results for each section are presented in independent tables beginning with communication skills in table 27.

Table 27 Results of stakeholder questionnaire- Communication

Question- Communication Section	**Yes**	**No**	**Comments**
Did the child use P.E.C.S. symbols in the home/school prior to using the App?	12	2	
Did the child use P.E.C.S. symbols in the community prior to using the App?	9	5	

Did the child, at any time, use the App to communicate needs or wants while in the home/school?	10	4	
Did the child use the App to communicate needs or wants while out in the community?	4	10	
Did the child show preference to using the iPad and App as opposed to their P.E.C.S. folder?	4	8	one survey: "not sure"; one survey: "does not have P.E.C.S. folder at home"
Did the child show willingness to engage with the App?	12	2	one survey: "very little and very difficult"
Did the child's sentence structure increase?	8	6	one survey: "non-verbal; no"
Did the child learn to vocalise new words as a result of engaging with the App?	6	8	
Did the child attempt vocalisation of words as a result of engaging with the App?	6	8	

The results indicated in table 27 above indicate some key themes in relation to the effectiveness of this intervention for communication which include: willingness to engage, increase in sentence structure and initiation of communication. The questionnaires evidenced that 85% of participants independently showed interest in the App and were willing to engage with it for the purpose of communication. Bernardini et al. (2014), evidence that this can be attributed to their innate abilities to navigate the devices which sparks their motivation to communicate. As a result of this intervention, 57.14% of participants increased their sentence structure, be it verbally or through the use of the App. Chien et al. (2015) and McEwen (2014), identified similar increases amongst participants with Chien et al. (2015) reporting increased instances on expressive communication and McEwen (2014) reporting individual improvements. This is an important finding in relation to the potential use of this App with other groups of children and the P.E.C.S. phase that they were currently engaging with. As outlined in chapter two, there are six phases of P.E.C.S. (Frost and Bondy, 2002); thus, as a result of this intervention a number of the participants progressed onto a higher phase. The instances of initiation of communication also increased amongst participants with 71.5% of participants utilising the App to make a request. The two lowest scoring questions were focused on the use of the App within the community and also

preference amongst the children to using the P.E.C.S. App as opposed to the P.E.C.S. folder. In contrast to these findings, De Leo et al. (2010), reports that children with ASD prefer to use mobile devices and Apps in comparison to P.E.C.S. folder. With Harrell (2010), attributing this to the fact that children with ASD are visual learners and they show preference to interacting with technology. The feedback gained directly from participants highlighted that the majority liked to use their App to communicate. The increased levels of communication also impacted upon the levels of social inclusion experienced by the children.

Table 28 Results of stakeholder questionnaire- Social Inclusion

Question- Social Inclusion Section	**Yes**	**No**
Did the child initiate engagement with you while using the iPad and App?	6	8
Did the child initiate engagement with siblings/peers while using the iPad and App?	4	10
Did the child ever engage with extended family, friends or members of the public/ staff outside of the classroom while using the iPad and App?	3	11

Due to the symptomology of children with ASD, the concept of social inclusion is one that can cause frustration and anxiety. The results from the questionnaire highlight that social inclusion did occur for some children; however, for the majority it was not successful. This questionnaire indicated that 28.57% of participants engaged in peer to peer interaction. As highlighted by Hayes et al. (2010), this is not a common feature amongst children with ASD. Therefore, even though this percentage appears small, due to the symptomology of ASD it is an encouraging figure. As stated by Sennott and Bowker (2009), the “coolness” factor of the devices and using the device as a medium are catalysts for the increase in social inclusion amongst children with ASD.

Table 29 Results of stakeholder questionnaire- Independence

Question- Independence Section	**Yes**	**No**	**Comments**
Did the child use the camera feature to take their own images?	5	9	
Did the child show interest in using the camera feature?	7	7	one survey: "did not try it with [participant]";
Did the child show the ability to potentially learn how to independently use the camera feature?	8	5	one survey: "did not use it enough with [participant]"
Did the child engage with the images within the App that you assisted them to take?	9	3	one survey: "did not take any for them"; one survey: unanswered
Did the child take control of their iPad?	6	8	
Did the child learn to request when the device needed to be charged?	3	11	
Did the child charge their device independently?	4	10	

The concept of independence was explored through two stems; management of vocabulary and control over their device. The camera feature within the App was key to facilitate the development of the management of vocabulary as this was how the participants added new symbols to their device (Nagurski, 2010). According to stakeholders, 57.14% of participants displayed the potential to learn how to independently navigate the camera feature; while 35.71% of participants were already developing their own symbols. One stakeholder stated that they 'did not use it enough' to be able to definitively say if the participant had to potential to learn independent navigation of the camera feature.

Table 30 Results of stakeholder questionnaire- Attention Span

Question- Attention Span	**Yes**	**No**	**Comments**
Did the child engage in tasks for longer periods of time?	8	6	
Did the child engage for greater periods of time when communicating with you or others?	7	6	one survey: "not used much with [participant]"
Did the child's attention span increase as a result of using the iPad and App?	7	7	

Wingrad (2010), evidenced that the symptomology of ASD includes difficulty with focus; thus, resulting in short attention spans. This can be impacted upon by external sensory stimulations such as light, sound, smell, etc. However, as outlined in chapter two De Leo et al. (2010), reported that there was an increase in participant's attention span as a result of utilising mobile devices and communication Apps. This was also evident in the results of this research with stakeholders evidencing that 57.14% of participants engaged in tasks for longer periods of time as a result of the intervention.

Table 31 Results of stakeholder questionnaire- Behaviour that Challenges

Question- Behaviour that Challenges	**Yes**	**No**	**Comments**
Does the child engage in behaviour that challenges?	11	3	
Has the occurrence of incidents decreased?	5	6	
Has the duration of behaviour that challenges decreased?	5	6	
Has the child learned to express what is causing them upset?	5	8	
Was the P.E.C.S. App an effective intervention for the child?	9	3	one survey: "there was far too much for [participant]. If it was just about 10 symbols I think we would have had much more success."

The engagement in behaviours that challenge appeared as a common thread amongst children with ASD. Bradshaw (2015), highlights that one of the potential causes of this is impairment in the area of communication. Thus, as a result of increased opportunities to communicate a child's incidents of behaviour that challenges should decrease. 78.57% of participants engaged in behaviours prior to commencing the intervention. Post-intervention the occurrence and duration of incidents had decreased amongst 45.45% of these participants. This proportion of participants also learned how to express what was causing them upset during the intervention. Thus, the development of coping mechanisms emerged amongst 45.45% of participants. Stakeholders also provided extra feedback and recommendations for future developments which are displayed in the table below. Overall, stakeholders reported a 75% effectiveness rate of the overall intervention for participants.

These questionnaires presented the results collected from stakeholders at two points within the implementation phase. The formative results highlighted modifications that were required immediately along with recommendations for future developments. The second questionnaire focused on the summative while addressing the effectiveness of the intervention for the children from the stakeholder's perspective. The results were parallel with those of the literature; however, individual results are discussed in greater depth and breadth in section 5.4.

In conclusion, the use of quantitative tools played an important role in both the formative and summative testing of the App. The ATEC, questionnaires and usability testing contributed to the development of user requirements along with evaluating the effectiveness of the App for participants. The results presented above provide an outline of the overall results with the intervention proving successful for the majority of participants. The ATEC and questionnaires were important for the evaluation of the App and were triangulated through the use of qualitative methods that were presented throughout this chapter. The following chapter provides an extensive account of each participant through the triangulation of methods used throughout the research.

5.4 Participant results while utilising a Mixed Methods Approach

5.4.0 Introduction

As previously stated within this dissertation the presentation of results and findings holds a particular focus on the individual. The purpose of this section is to clearly identify each participant's development while assessing this development against their baselines prior to the implementation of the intervention. It is important to note that prior to discussing the results of each child that five out of ten participants accessed the App and device while only in school. This results from the lack of engagement from parents. The researcher held meetings prior to the implementation phase and during this meeting stakeholders were requested to sign a contract of purpose (See Appendix KK). The purpose of this was to ensure that stakeholders would not potentially jeopardise the results of the intervention by downloading other Apps onto the device. After numerous attempts to liaise with all parents the researcher was successful in meeting with five parents; thus, those participants utilised the App and device both at home and in school. The presentation of the results take on a holistic approach with the inclusion of tools such as the ATEC, observations, interviews and questionnaires.

5.4.1 Participant 1

The results gathered to explore the effectiveness of the use of communication Apps through mobile devices for this participant included the use of the ATEC, observations, a questionnaire and U.T. This participant utilised the communication App while in school. The participant is non-verbal.

Upon implementation of the App, a U.T. session was conducted with the participant and it was evidenced that he appeared to be having difficulty independently navigating the interface for the purpose of communication. However, during this session he did engage with the App. Initial observations highlight that the participant required consistent encouragement to remain engaged in academic tasks; thus, suggesting a short attention span. This participants ATEC baseline

assessment scored 88; thus, rating at the higher end of the spectrum as the tool is rated out of 180.

During assessment one, the classroom teacher reported that the participant was unable to utilise the App. This difficulty was being attributed to the amount of vocabulary available within the App and the participant's short attention span. Upon completion of a vocabulary checklist, stakeholders did not identify the participant's limited vocabulary, but instead requested items across all categories to be included within the App. The mid-intervention questionnaire (formative testing) evidenced the difficulties being encountered by the participant. Two primary recommendations were made by the stakeholder with the aim of overcoming these barriers to participation: 1) reduce the amount of symbols available and 2) increase the size of the images. The participant was currently using two paper based symbols (personal photographs) which were much bigger in size; thus, creating this familiarity could potentially increase interaction with the App. As a result of this feedback, the researcher created a Lite[13] version of the App specifically for this participant. The researcher requested the images from the classroom teacher; however, they were not received until week seven of the intervention. As a result of this, the researcher was unable to implement the Lite version as there was a risk of creating inconsistencies within results collected. The participant would not have been exposed to the new version of the App for long enough to collect data that was valid and reliable. Thus, the decision was taken to continue the implementation as set out in the plan. The ATEC assessment for this observation indicated a score of 85; thus, little improvement had been made. The following observations and assessments highlighted minor improvements with scores of 72 and 71 respectively. However, during observation three it was noted that the participant's devices was locked away in a filing cabinet. The final assessment indicated a score of 82 with observations evidencing communication through objects of reference (physical item) and utilisation of eye contact during communication. The participant refused to provide feedback on the App.

[13] Lite version refers to an App with 'limited functionality'(Davis, 2016, pg.1).

In conclusion, these results indicate that there were barriers to implementation that had the potential to be overcome. The participant showed an average improvement of 10.5 and this was evident in his final assessment of the initiation of communication and engagement in eye contact. Potential barriers to the success of this intervention are discussed in Chapter 6.

5.4.2 Participant 2

An assessment of the effectiveness of this intervention for participant 2 was based on the collation of results from the ATEC, observations, U.T. and stakeholder feedback. This participant utilised the App and mobile device through a holistic approach; home and school. The participant is verbal.

During the first week of the implementation phase the researcher conducted a U.T. session with the participant. The participant demonstrated independent navigation of the App in an effective and efficient manner. The only task that the participant did not complete independently was engaging with the camera feature within the App; however, this was not a concern at this time as a stakeholder interview previously indicated that the participant was already independently using the camera App on her own iPad at home. The written plan of implementation also provided guidance on this for stakeholders to effectively teach the skill. The baseline assessment was conducted during this session and the participant received a score of 55. The observations evidenced three out of the six key themes: motivation to engage with the App, communication and attention span. The participant was scanning symbols on the interface and engaged in two instances of spontaneous communication. However, attention span was short during academic activities with external factors causing distraction i.e. people and objects within the classroom. The following four assessments evidenced significant improvements for this participant.

Assessment one and two both scored at 38 with two themes being evidenced in assessment one observations and three themes being evidenced in assessment two observations. Two themes that were evidenced in assessment one were behaviour that challenges and attention span. The participant's behaviour that challenges was not evidenced today and the participant 'appeared calm'. The

participant's attention span saw a dramatic increase with engagement in academic tasks lasting 50 minutes. The mid-term questionnaire was distributed during this week and results from stakeholders indicated that the participant did not have any difficulties utilising the App for the purpose of communication. However, it is important to note that the camera feature was not yet being taught to the participant. A stakeholder stated in the question focusing on this topic 'I have not let her at it at this stage. I have taken photos of snacks that needed to be added'.

Assessment two saw the emergence of three key themes; attention span, communication and social inclusion. Attention span again referred to academic tasks and communication occurring in the form of spontaneous instances. The initiation of social inclusion was brought about by a peer; however, the participant engage with the peer for the purpose of an activity (bubbles). This was the first instance of peer to peer interaction that was observed in both the informal (pre-intervention) and formal (during intervention) observations.

Assessment three evidenced the lowest score for this participant in relation to the ATEC with a drop to a score of 30. This observation also evidenced the first instance of the development of independence for the participant. The participant began taking control of their device and was independently navigating through the App to engage in spontaneous communication. This observation also evidenced a progression in P.E.C.S. phases. The participant independently transferred from level one to level four as she began her sentence with the 'I want' symbol. This can be attributed to the consistency of availability of the symbol (first symbol on each page) or the prompting received from stakeholders (mid-term feedback questionnaire). This assessment along with assessment four were the pivotal points of the effectiveness of the intervention for this participant.

The final assessment (assessment four) was the first time there was a simultaneous emergence of all six themes: communication, social inclusion, independence, attention span, behaviour that challenges and motivation to engage with the App.

Table 32 Final assessment themes

Theme	Evidence
Communication	Increased verbal abilities: began using 'I want' during verbal requests, Spontaneous communication: requesting items using the App (fruit, raspberries).
Social Inclusion	Initiating engagement with staff to request items- making eye contact.
Independence	Engaging with the camera feature. This was the first interaction with the camera feature within the App. Once the teacher demonstrated its use the participant independently took an image. Staff assisted with the labelling of the image; however, participant remained engaged during this.
Attention Span	Prolonged engagement in academic tasks.
Behaviour that Challenges	No behaviours present today.
Motivation to engage with the App	Continuous engagement without prompting or assistance. Scanning of symbols within the App.

The final ATEC assessment and observation indicate that this was an effective intervention for this participant in all six key themes. However, in consultation with the stakeholder evaluation questionnaires there are some discrepancies. These discrepancies vary in the areas of preference to modality, interest in the camera feature, taking control over the iPad and increased attention span. Potential reasons for this are discussed in Chapter 6. The participant provided feedback on the App and through the use of P.E.C.S. symbols (See Appendix QQ) identified that she liked the App.

In conclusion, the triangulation of the mixed methods tools utilised in the data collection phase identify that this was an effective intervention for this participant. Participant two's scores decreased from 55 to 35 in the ATEC, resulting in 36% effectiveness during the intervention. A combination of observations and stakeholder feedback triangulated these results. During the duration of these observations the participant's progress was clear with benefits in all six key themes being evidenced in the final assessment.

5.4.3 Participant 3

In order to assess the effectiveness of this intervention for participant 3 the tools utilised were the ATEC, observations, U.T. and stakeholder feedback. This participant utilised the App and mobile device during school. It is important to note that prior to presenting this participants results only five out of the six key themes were applicable to the participant. As identified in the participant profile which was completed at the beginning of the UCD process, the participant did not engage in behaviour that challenges; thus, this theme was not applicable to her. The participant is verbal; however, her verbal abilities are limited.

Upon implementation of the mobile device and App, the researcher conducted U.T. with the participant. The U.T. session indicated that the participant independently navigated every aspect of the App with the exception of the camera feature. Thus, there were no reservations about the potential of the intervention for this participant. The participant's baseline score was rated at 29 on the ATEC.

Assessment one saw an immediate decrease on the ATEC with the participants score dropping to 24. The participant also evidenced four out of the five key themes in this assessment; motivation to engage with the App, independence, communication and attention span. The participant showed instantaneous interest in the mobile device and explored it for a few seconds before independently opening the App. The participant began navigating the categories independently and began attempting verbalisation of words after hearing the voice output from the App (verbal abilities). The sentence structure aspect of the App was mastered immediately along with the functionality of 'the expand' and cancel buttons. The participant then began using the App to request items that she could see but did not have access to (spontaneous communication). The attention span of the participant increased immediately as she sat for thirty minutes, without prompting or encouragement, to utilise the App. Thus, the impact of the intervention could be observed immediately; particularly, in the area of language acquisition (spontaneous communication and verbal abilities). The developments in this area were also evidenced within the stakeholder feedback questionnaire at the completion of the

intervention. The second and third assessments saw similar gains being made by the participant.

Assessment two saw a further decrease in the ATEC to 19 and evidenced four key themes during the observations; attention span, independence, communication and social inclusion. The participant remained engaged in academic tasks as per instruction from the teacher and did not require prompting. The participant independently opened and navigated the App along with scanning an extensive vocabulary that was available within the App. The participant initiated communication with the teacher through independently constructing and presenting a sentence. The participant also initiated engagement with a peer through the use of bubbles. As stated by Campigotto et al. (2013), this was a rare observation to witness especially in a special needs classroom. This was the first instance of peer to peer interaction that was observed by the researcher through both the informal and formal observations.

Assessment three was the final assessment undertaken for this participant due to absenteeism. The participant was absent for assessment four and remained absent for the duration of the researchers time on site. This assessment again identified a drop in ATEC scores with a drop of 3 points on the previous score to reach 16. All five key themes were evident throughout this observation; independence, motivation to engage with the App, attention span, social interaction and communication. Upon receiving the mobile device and App the participant refused to engage with any other academic tasks offered and insisted on engaging in communication exchanges with the teacher. The participant also made gains in relation to the P.E.C.S. phases where she was observed independently transferring from phase 1 to 4. The participant began using the 'I want' symbol when constructing sentences. This was triangulated through the stakeholder feedback questionnaire. The participant's attention span remained with engagement lasting approximately 30 minutes; to which she then initiated interaction with another peer. She also began assisting this peer with academic tasks which as evidenced by Chen (2012) is as a result of utilising mobile devices and communication Apps. This was again the first instance of peer assisted learning that was observed by the researcher during informal and formal observations. The participant was introduced to the camera

feature within the App for the first time during this observation; however, the participant did not receive access to the mobile device at this time. The teacher began taking images for the participant but the participant was not involved or encouraged to try during this time. Thus, independence of the camera feature was not achieved during the intervention. The stakeholder feedback questionnaire identified that the participant had the interest and potential to learn how to navigate the camera feature independently.

In summary, the collaboration between the ATEC, observations and stakeholder feedback questionnaires identify that this was an effective intervention for the participant. The participant made clear progress in all five themes; communication, independence, social inclusion, attention span and motivation to engage with the App. The theme of communication was particularly successful with gains made in the areas of language acquisition (spontaneous communication and verbal abilities). This was replicated in the ATEC scores with scores decreasing from 29 to 16 resulting in an overall improvement of 32%.

5.4.4 Participant 4

Participant 4's progress was assessed through the utilisation of the ATEC, observations, U.T. and stakeholder feedback questionnaires. This participant utilised the mobile device and App in both the home and school contexts. The participant is non-verbal.

This participant's baseline assessment identified a score of 107; thus, when placed in context the participant was borderline severe as per the ATEC. This difficulty was evident in the U.T. session with the participant having difficulties navigating the expand and cancel button and taking longer than other participants to complete tasks. However, when given extra time the participant demonstrated potential for competency. The participant's attention span was short during academic tasks and he required encouragement to engage both initially and during
tasks.

Assessment one evidenced a significant decrease in ATEC scores with a result of 69 emerging. The observations highlighted the participant's motivation to engage and an increase in attention span. The participant began exploring the App and the

vocabulary available within it. The participant sat and engaged for approximately twenty minutes with the App.

Assessment two saw similar gains and a further decrease in scores to 66 on the ATEC. This assessment evidenced two themes; communication and attention span. The participant engaged with the App without encouragement for approximately fifteen minutes. The participant began using the App independently for the purpose of communication. An instance of spontaneous communication occurred when the participant had scanned the available vocabulary and independently selected 'fruit shortcake biscuit'. The participant also transferred from P.E.C.S. phase one to four independently. He utilised the 'I want' symbol for the purpose of sentence structure. He also verbalised 'bye bye' when he wanted to finish using the App. The development of language acquisition was clearly evident within this assessment; both verbally and through using P.E.C.S.

Assessment three saw a more significant drop in ATEC scores to 49 and again evidenced three themes: motivation to engage with the App, communication and attention span. Communication manifested in spontaneous communication and attention lasted approximately twenty minutes.

The final assessment saw a rise in ATEC scores to 55 and the emergence of two themes; independence and communication. The participant was independently scanning, scrolling and selecting images for sentence structure. Communication was evident in the area of spontaneous communication; requesting food and clothes items along with engaging in phase four of P.E.C.S. The stakeholder feedback questionnaires evidence discrepancies, for example, one stakeholder evidences increased sentence structure whereas the other stakeholder stated that the participant did not receive benefits in the area of sentence structure. Stakeholder feedback focused on the functionality of the App as opposed to the effectiveness of the intervention. For example, customisation and control of the mobile device and vocabulary were identified on the feedback sheet as opposed to focusing on the individual participant and their progress. Potential reasons for these divergences are explored in chapter 6. The participant refused to provide feedback on the App.

In conclusion, throughout the duration of this intervention the participant demonstrated improvements in four of the key areas; communication,

independence, attention span and motivation to engage with the App. Social inclusion was not evidenced for this participant for the duration of the intervention with respect to peer to peer engagement or members of the wider community. The participant engaged and communicated with their parents and special needs assistant with whom they are very familiar with. The ATEC scores triangulate these improvements with a 44% decrease in the participant's scores from baseline to the end of the intervention. Therefore, the intervention proved successful this individual.

5.4.5 Participant 5

Participant 5 was assessed while utilising the ATEC, observations, U.T. and a stakeholder feedback questionnaire. The participant utilised the mobile device and App while at school. As outlined in section 5.3.1, the assessment of the intervention was suspended at the beginning of assessment 3 due to personal circumstances for the participant. The researcher, being a social care professional, felt it would be unethical and unsafe to proceed with observations and assessments. The participant proceeded with the intervention for its duration and the researcher continued to liaise with the teacher to provide off-site support. The participant is non-verbal.

The baseline ATEC assessment evidenced a score of 85; thus, ranging in the middle of the spectrum. U.T. was conducted during this session and indicated competencies in all areas expect for the camera function. Thus, indicating that the participant would not need to overcome any personal barriers to navigate the App.

Assessment one evidenced a drop in ATEC scores to 77 and the presence of two out of six themes. The themes that were evidenced in this assessment were: motivation to engage and attention span. Motivation to engage with the App was evidenced during circle time. The participant refused to engage in circle time; however, when his mobile device and App were made available he joined circle time. When the teacher ceased utilising the App, the participant returned to his sensory corner. The participant remained engaged for its duration; however, his attention span was limited to approximately one to two minutes per task.

Assessment two identified a significant drop in ATEC scores to 47. Three themes were identified during this session; communication, motivation to engage

with the App and social inclusion. The participant is non-verbal; thus, the presence of communication was through vocalising to which staff responded. The participant was motivated to engage with the App as he engaged in scanning of vocabulary and interacted with the interface. He also initiated peer to peer interaction through eye contact. Again, this was the first instance observed by the researcher during informal and formal observations. The participant also initiated engagement with the researcher where he approached, made eye contact and vocalised. Stakeholders expressed their concern for the participant during this assessment stating that he was experiencing difficulties at the time which were resulting in behaviours that challenge. Stakeholders also stated during the assessment that 'he [the participant] would do well with the App if we had time to teach it with him'.

Upon arrival for assessment 3 it became clear to the researcher the extent of the difficulties that the participant was experiencing. Thus, the decision was made to suspend assessments. The participant continued with the intervention but his progress was not being monitored formally.

In conclusion, for the short time that the participant engaged with the App (seven weeks) the potential impact for the participant was clearly evidenced. The participant received benefits within three of the six themes and ATEC scores clearly evidenced the potential with a 27% improvement. The stakeholder feedback questionnaire evidenced that the behavioural issues occurring at the time had a significant impact on the effectiveness of the intervention for the participant.

5.4.6 Participant 6

The assessment of participant 6's progress was assessed based on the ATEC, observations, U.T. and a stakeholder feedback questionnaire. This participant utilised the mobile device and App while at school. This participant shared a classroom with participant 5, subsequently her assessments were also suspended on assessment three. The participant continued to utilise the mobile device and App for the duration of the intervention. The participant is non-verbal.

The baseline assessment for this participant indicated a score of 80 on the ATEC scale. U.T. was also conducted and results indicated independent use of all

features with the exception of the camera. Thus, navigation of the App was not a barrier to access for this participant.

Assessment one evidenced a significant drop in ATEC scores to 67 and the presence of four key themes. The themes included: behaviour that challenged, motivation to engage with the App, independence and attention span. A short instance of behaviour that challenges occurred during transitions between activities. Attention span was short lasting approximately two to three minutes per activity and was easily distracted during activities. However, she demonstrated motivation to engage with the App by seeking access to her mobile device. The participant displayed aspects of independence by taking control of the device and carrying it independently. Stakeholders stated during this assessment that the participant 'has great potential to use it [App] but there are too many distractions and she needs more practice'.

Assessment two identified further improvements with an ATEC score of 51 and the presence of five themes. The themes present in this assessment were: behaviour that challenges, motivation to engage with the App, social inclusion, communication and attention span. Immediately prior to the commencement of the assessment the participant had engaged in behaviours that challenge and was being supported by stakeholders. During circle time and lunch time the participant engaged with the App and requested food. Her attention span had also increased in comparison to the previous assessment. The participant is non-verbal; spontaneous communication occurred with staff to request a sensory item that has a calming effect on her. A short time later this participant engaged in social interaction (eye contact) with her peer.

As previously outlined, assessment 3 and 4 were suspended due to difficulties being experienced by a peer. However, the results gathered from the first half of the intervention were encouraging for this participant.

In conclusion, this participant experienced gains in four out of the six key themes; communication, social inclusion, motivation to engage with the App, attention span and independence. The observations and stakeholder feedback questionnaire concurrently evidenced that behaviours that challenge remained present and the intervention did not appear to impact upon alleviating them. Overall,

the preliminary results highlight that this was an effective intervention for this participant with a 26% improvement.

5.4.7 Participant 7

Participant 7 was assessed through the utilisation of the ATEC, observations, U.T. and stakeholder feedback questionnaires. This participant utilised the mobile device and App while at home and at school.

The baseline assessment provided a score of 68. The participant also engaged in U.T. during this session. The participant demonstrated competencies in all features of the App with the exception of the camera feature. This participant is non-verbal.

Assessment one identified an immediate drop in ATEC scores to 57 with the presence of three themes; independence, social inclusion and communication. The participant took control of his device and began requesting lunch with it. He also initiated interaction with stakeholders through eye contact.

Assessment two again evidenced a drop in ATEC scores to 51. However, the participant appeared tired during the observation and required assistance from stakeholders during activities. The participant had moved classroom in between assessments; thus, his routine had changed in recent days. This had an inevitable impact upon the participant due to his symptomology.

Assessment three saw the greatest decrease with a score of 43 and the presence of two themes; social inclusion, attention span and communication. Social inclusion occurred through initiation of engagement with staff. Attention span appeared to increase with engagement in academic tasks lasting approximately 30 minutes. It appeared to become evident during observations that the participant preferred to use paper P.E.C.S. symbols as opposed to the mobile device and the App. The stakeholder feedback questionnaires triangulated this finding. A stakeholder later stated during the observation that ‘I just haven’t been using it [App] with him’.

Assessment four evidenced a significant increase in the ATEC score to 56 with the emergence of one theme; communication. The participant engaged in providing feedback on the App through the use of a choice board. The participant independently indicated that he liked to use his App through the use of symbols.

In conclusion, the participant received benefits in four of the themes which included: social inclusion, communication, attention span and independence. The ATEC scores triangulate this with an overall improvement of 24%.

5.4.8 Participant 8

The effectiveness of the intervention for participant 8 was evaluated based on the collaboration of the ATEC, observations, U.T. and stakeholder feedback questionnaires. The participant is verbal; however, he utilised P.E.C.S. as a support. He engaged in this intervention through a holistic approach and utilised the mobile device and App while at home and in school.

The baseline assessment produced a score of 42. The participant engaged in U.T. of the App during this session. These results indicated full independent competencies in navigating all features of the App with the exception of the camera feature. There was an emergence of two themes during this observation; communication and social inclusion. The participant showed empathy for a peer and initiated peer interaction by asking 'what is wrong'. This was a behaviour that had not previously been observed.

Assessment one saw an immediate decline in the ATEC scores to 39 and the presence of two themes; independence and motivation to engage with the App. The participant showed immediate interest in the mobile device and the App. He had one personal image (deskwork) located in the App that staff assisted him to take earlier in the week. The participant was exploring the use of the camera feature within the App during this assessment. Upon further exploration of the participant's mobile device it became clear that he had been using the native camera App within the mobile device to take his own images. He had twenty-two images in the gallery at the time.

Assessment two saw an increase in the scores to 45 and the emergence of three themes; social inclusion, communication and behaviour that challenges. Upon arrival for the assessment the researcher noted that there were extra people in the classroom (students) that were not normally there; thus, changing the participants routine and impacting upon his behaviour. The participant engaged in behaviour that challenged as a result of concern for his peer during which he began communicating

to staff, his peer and also himself. He utilised communication as a coping mechanism to manage his behaviour. Social inclusion occurred sporadically throughout the session with stakeholders and peers.

Assessment three evidenced a substantial drop in the ATEC score to 26 and evidenced three themes; communication, behaviour that challenges and social inclusion. Communication improvements occurred in the area of verbal abilities with the vocalisation of new words. Behaviours that challenge occurred during this observation; however, as stated by staff an external cause holds the potential to impact upon this that neither staff or the participant could control. The participant engaged in peer to peer interaction through using the mobile device as a medium. The participants engaged through the camera feature of the App as his peer was including him in his personal vocabulary.

The final assessment saw a further decrease in scores to 20. The participant also provided feedback on the App and when asked if he liked the App he responded 'yes App' and utilised the P.E.C.S. symbols as a support to confirm his answer. The stakeholder feedback questionnaires triangulated the results found in the ATEC and observations; however, the depth of effectiveness of the intervention is also highlighted within the questionnaires. The questionnaires identified that:

1. Prior to the intervention the participant did not utilise P.E.C.S. in the home; however, as a result of the intervention he began using them in the home,
2. He showed preference to using a mobile device and App as opposed to a P.E.C.S. folder,
3. His sentence structure and verbal abilities increased,
4. He learned how to independently navigate the camera feature so as to manage his own vocabulary,
5. He took control of his device and not only learned when it required charging but learned how to charge it independently,
6. He utilised the mobile device as a medium to engage with stakeholders, siblings, family, friends and members of the public,
7. His attention span increased and

8. His incidents of behaviour that challenges decreased along with their duration. He also learned how to express the trigger for the behaviour and how to request coping mechanisms.

In conclusion, this participant received benefits in all six key themes: communication, independence, social inclusion, attention span, behaviours that challenge and motivation to engage with the App. The ATEC scores identify an overall improvement of 22%; however, the stakeholder feedback questionnaires provide greater depth to the impact that the intervention had on this participant.

5.4.9 Participant 9

The effectiveness of this intervention for participant 9 was identified through the collaboration of the ATEC, observations, U.T. and stakeholder feedback questionnaires. This participant is verbal. The participant utilised this intervention through a holistic approach by engaging with the App at home and in school.

The baseline scores for this participant were identified as 44. The participant engaged in U.T. and the results indicated that he was independently navigating all aspects of the App. This session evidenced engagement in three themes; behaviours that challenge, communication and social inclusion. The participant engaged in behaviours that challenged on two occasions; however, he engaged in communication both times to request assistance from staff. He also engaged in one instance of spontaneous communication with stakeholders. He initiated interaction with staff through utilising the mobile device as a medium and also initiated interaction with a peer through eye contact and facial expressions.

Assessment one evidenced a dramatic decrease in ATEC scores with a result of 26 and the emergence of all six key themes. During this assessment the participant demonstrated an increase in communication, motivation to engage with the App, social inclusion, attention span, independence and behaviours that challenge. Increased verbal abilities were evident during engagement with the App. The participant would repeat words upon hearing the voice output. His motivation to engage with the App was undeniable and he engaged independently. His attention

span had seen a noticeable increase through sitting for academic tasks for longer periods of time. The participant did not engage in behaviours that challenge at any time throughout this assessment; this was the first time the researcher had observed this during informal and formal observations. The participant's independence increased dramatically during this assessment. He has taken control of his device and App and was independently managing his vocabulary. He was also utilising the device as a medium to engage in peer to peer interactions. The participant had nineteen personalised symbols in his App and had forty-three images in the devices camera App. Stakeholders reported during this assessment that 'he loves the independence' and he has also learned when and how to charge his device. During researcher and stakeholder engagement the participant initiated engagement with both and included himself within the social interaction and also the communication.

Assessment two saw further improvements with a decreased score of 18 and engagement in all six themes. The participant engaged in spontaneous communication and peer to peer interaction simultaneously. He continued to learn new words and repeat verbalisation of words as a result of the voice output. He engaged in spontaneous communication by utilising the App to say 'wash hands'. He also spontaneously requested 'cheerio's' and 'ham' for lunch with the App to which the stakeholder provided and he then verbalised 'cheerio's'; this was the first time he had verbalised cheerio's. Stakeholders stated during this assessment that 'he is getting new words every day, he is talking mad since he came back [from mid-term break]'. Social inclusion also increased with the participant not only initiating engagement with stakeholders but also his peers. His attention span again increased and motivation to engage with the App was evident throughout the session.

Assessment three saw an increase to 26 in the ATEC and the emergence of three themes. The participant engaged in behaviours that challenged for a short time; however, he communicated verbally the coping mechanism he required and also stated using P.E.C.S. that he was 'tired'. He initiated engagement with staff and engaged in eye contact.

Assessment four evidenced a significant drop to 13 in the ATEC scoring. The participant's engagement in communication saw a dramatic increase and there was also evidence of social inclusion. Communication varied from spontaneous

communication to increased verbal abilities. The participant independently verbally greeted his peer, sang songs and engaged in conversation. He also requested 'deskwork' and 'lunch' while using the App. The stakeholder feedback questionnaires triangulated all of the above improvements and indicated success on every question. Stakeholders stated that there were increased instances of communication not only with them but also peers, family and members of the community. Participant 9 had increased his independence through management of his own vocabulary and gaining control over his device. His social inclusion increased both at home, in school and out in the community. His attention span increased during academic tasks and during communication exchanges. His behaviours that challenge decreased and when they did occur he has learned to express his needs so as to implement coping strategies.

In conclusion, this participant received a 52% improvement as a result of engaging with this intervention. He received benefits in the six key themes; communication, independence, motivation to engage with the App, social inclusion, attention span and behaviours that challenge. The utilisation of the ATEC, observations and stakeholder feedback questionnaires provided evidence of great depth and breadth in relation to the effectiveness of the intervention for this participant. The participant was the final seal of approval with his feedback and through the use of P.E.C.S. symbols he indicated that he liked the App.

5.4.10 Participant 10

Participant 10 was assessed based on the collection of data from the ATEC, observations, U.T. and a stakeholder feedback questionnaire. The participant is verbal; however, he has limited verbal abilities. He utilised the App while only in school.

The baseline assessment located a score of 69 on the ATEC. The participant engage in U.T. during this session with the results highlighting that the participant could independently navigate all features of the App. All six of the themes emerged immediately for this participant; social inclusion, communication, behaviour that challenges, motivation to engage with the App, attention span and independence. Through the utilisation of the App the participant began engaging in spontaneous communication and subsequently as a result of the voice output developed increased

verbal abilities. He utilised the camera function to engage in peer to peer interaction with two peers separately. The participant engaged in self-injurious behaviour for a moment and then utilised the mobile device to which the behaviour ceased. The participant's attention span instantly increased during circle time and his motivation to engage with the App was evidenced throughout his engagement with the vocabulary and the camera feature. His independence soared as he engaged with the App. During teaching of the intervention the participant held the teachers hand and took her to the press, she stated that she knew what he wanted so she would take a picture of it for him; he wanted a rice krispie square bar. The teacher proceeded to pick up the participants mobile device to which the participant intercepted. He tapped on the camera function, focused the camera and took a picture of the item. He then took his device away from the teacher. The teacher and researcher continued observing but the actions that were to follow were something that was unimaginable. The participant tapped on the text box beside the image and typed 'squares' to represent the rice krispie square bar and proceeded to save the new symbol. The teachers, special needs assistants and family were unaware that this child could spell. This was not the end but the beginning of this participant's success with the intervention.

Assessment one saw a slight decrease in scores to 64; however, five of the themes were present throughout. The five themes were: social inclusion, independence, motivation to engage with the App, attention span and behaviours that challenge. The participant continued to initiate peer to peer interaction through using the device as a medium. His independence continued to increase as he was independently managing his vocabulary. He had eighty-one images in the device camera App and twenty-nine personal symbols created within the App; thus, he was selective as to the vocabulary he included in his App. His attention span saw a dramatic increase as he engaged with the App for approximately thirty minutes. The participant did not engage in behaviour that challenged; this being the first time as observed by the researcher during informal and formal observations.

Assessment two saw a drastic decrease in ATEC scores with a result of 40 and the emergence of three themes; behaviour that challenges, communication and social inclusion. Behaviour that challenged occurred in the first ten minutes of the session

and then ceased. This in itself is progression from previous sessions where several incidents had occurred. He continued to increase verbal abilities while engaging in peer to peer interactions. The peer to peer interactions occurred across numerous peers and took the form of utilising the mobile device and App along with engaging in activities (dancing and bubbles).

Assessment three evidenced greater decline to 31 on the ATEC and the observation of four themes; attention span, social inclusion, behaviour that challenges and independence. His attention span during academic activities had seen a significant increase along with decreased behaviours that challenge. The participant did not engage in behaviours that challenge at any time during this assessment. Social inclusion continued to manifest as a result of utilisation of the mobile device and independence occurred through the camera feature.

The final assessment saw an increase to 40 on the ATEC and the presence of two themes; communication and behaviour that challenges. The instances of spontaneous communication increased significantly throughout the session along with his verbal abilities. Instances of behaviour that challenges were evident; however, the participant demonstrated progress within this as he independently verbally requested his chew toy which acts as a coping mechanism. This was the first time this occurred throughout the research. The stakeholder feedback questionnaire triangulated that the participant:

1. Received gains in language acquisition (spontaneous communication and verbal abilities),
2. Demonstrated a preference for the use of the communication App and mobile device as opposed to the P.E.C.S. folder,
3. Increased sentence structure
4. Independently managed his vocabulary,
5. Increased social inclusion amongst peers and members of the public,
6. Increased attention span
7. Decreased instances and duration of behaviours that challenge along with independently learning to request coping mechanisms.

The participant also agreed to provide feedback on the App and indicated through the use of P.E.C.S. symbols that he liked the App.

In conclusion, it is clear from the evidence outlined above that this intervention was successful for this participant in all six themes. The ATEC identified a 36% improvement; however, the observations and stakeholder feedback questionnaire identify the true depth of the success of the intervention. Through the use of mixed-methods tools a perspective of depth and breadth on the effectiveness of the intervention for this participant has been clearly presented.

5.5 Chapter Summary

It is clear from the evidence highlighted throughout this chapter that the intervention proved effective for every participant. Some participants received more benefits than others and there were discrepancies between stakeholders in the area of evaluating the effectiveness of the App; however, triangulation of the mixed methods approach provides a strong case for the effectiveness of the intervention. With stakeholder discrepancies, an effectiveness rate of 75% was received. The presentation of qualitative results highlighted that every participant made gains in a minimum of three of the six key themes. The ATEC scores evidenced improvements across all ten participant's; thus, based on the empirical evidence provided the use of this communication App and mobile device was an effective intervention for all ten participants.

Chapter 6: Discussions

6.0 Introduction

This chapter presents a discussion on the findings of the research while holding a particular focus on the overarching aim of the research along with answering the research questions as set out in the research proposal. This chapter is presented in three key sections: 1) P.E.C.S. and its adaptability to be used in the form of an App; 2) the interdisciplinary approach to the research; and 3) stakeholders presenting as barriers to the implementation of an intervention.

Section 6.1 addresses P.E.C.S. and the level of adaptability that can be achieved within an App format while addressing the impacts that the intervention had on participants. The impacts assessed were: communication, social inclusion, attention span, behaviours that challenge and independence. The usability of the mobile device and its suitability for children with ASD was also discussed.

Section 6.2 outlines a discussion on the interdisciplinary approach that was utilised during the research. This section focuses on two aspects: the researcher and the multi-disciplinary team within the research site. A discussion is presented in relation to the benefits of up-skilling a social care professional into the App development sector along with the benefits this knowledge brought to the research. The second stem being addressed is the involvement of stakeholders (parents, education professionals and SLT) at the earliest possible point within the research.

The final section addresses stakeholders as a potential barrier to the implementation of the intervention. Stakeholders play an important role within the life of the child; however, due to external influences they may unintentionally become an inhibitor to an intervention as opposed to acting as an enabler.

6.1 P.E.C.S. and its adaptability to be used in App form

As previously outlined throughout this dissertation, P.E.C.S. has been proven as an effective form of Augmentative and Alternative Communication (AAC), particularly for children with ASD. However, the available literature did not provide the same strength in proving the effectiveness of communication Apps for children

with ASD. One of the aims of this research was to investigate the effectiveness of communications Apps to enhance the effectiveness of P.E.C.S. In doing so, this research posed six questions that aimed to answer this primary question. The six questions were:

1. Do the children use the app more than the folder?
2. Does a child with ASD communicate more when using a communication app?
3. Is the child independent in managing the vocabulary library?
4. Is the child engaging in behaviours the challenge less frequently?
5. Is the child engaging more with parents and peers?- social interaction
6. Is the usability of the device suitable for children with ASD?

Prior to discussing these six questions in detail it is important to note that, as a result of engaging in this process it became clear that some of the limitations of P.E.C.S. could also be addressed through the development of a P.E.C.S. based communication App. The limitations that have the potential to be alleviated are the development of symbols and restricted vocabulary. The following sub-section discusses the potential to overcome these limitations through the use of a communication App with the remaining sub-sections addressing the six research questions as outlined above.

6.1.1 Overcoming the limitations of P.E.C.S.

The development of a communication App provided participants and stakeholders with the use of a symbol set that was consistent across settings. As seen in the results in Chapter 5, the availability of suitable and consistent symbols/images for children remains an issue. For example, creating Irish based symbols such as [Gaelic] football, hurling, Tayto and a school bus that 'isn't always yellow' (stakeholder interview). Relating the symbol set to the population of children participating in the research was one element in overcoming the limitations to P.E.C.S. The creation of an App would provide the consistency required for children and their stakeholders to engage in more effective communication. The elimination of paper based symbols also alleviated the limitations of P.E.C.S. as both stakeholders and the literature have identified that the development of symbols are laborious and time consuming (Flippin, Reska and Watson, 2011). P.E.C.S. is also known to restrict

the vocabulary of its user through the facts that stakeholders need to pre-empt the vocabulary required so as to develop the symbol and also a folder can only hold so many symbols. Thus, as the child's vocabulary grows so too does the size of the folder. This impacts on the child's use of the folder as it is cumbersome to carry and it also becomes more socially excluding as this is not a mainstream product within society. The element of restricted vocabulary is discussed in greater detail in section 6.1.3. Prior to its implementation and evaluation the development of the App occurred in partnership with Nano Nagle School. This was an essential element of the research as the development of an App based on empirical evidence was of significant importance. As a result of the gap in the literature of Apps based on empirical evidence the UCD process was of upmost importance.

6.1.2 Do the children use the app more than the folder?

As outlined in chapter 5 in the presentation of results, there were inconsistencies amongst stakeholders in their feedback. One area of inconsistency in particular was in relation to the children showing preference to using the mobile device and App as opposed to the folder. As a result of analysing researcher observations, this inconsistency can be attributed to potential confusion amongst stakeholders as to the meaning of P.E.C.S.

Upon reflection of the informal and formal observations and interview data it became clear that the meaning of P.E.C.S. was obscure amongst stakeholders. It was stated in the interviews that participants utilised P.E.C.S. throughout their days; however, upon observation it was noted that it was the visual schedule that was utilised consistently. Even though a visual schedule was utilised throughout the day; this is not classified as communication rather it is a supportive tool within the communication process (Frost and Bondy, 2002). The use of a visual schedule in isolation does not constitute the use of P.E.C.S. Some participants were being trained in P.E.C.S. sporadically; however, access to their folders was restricted. During the teaching of traditional P.E.C.S. it was also noted that participants did not show motivation to engage and relied on prompts to complete the communication exchange. If a participant did have a folder it was kept in a locked cabinet until the stakeholder presented it to them. None of the participants were independently

utilising a P.E.C.S. folder; therefore, prior to implementation of the intervention P.E.C.S. was not being utilised as a form of functional communication. As a result of this, the stakeholder's perception in answering this question was distorted. This is where the value of the researcher's observations could be drawn upon.

Upon analysis of the researcher's informal and formal observations it became evident that the children did show preference to using the mobile device and App as opposed to a P.E.C.S. folder. The results from the questionnaire and observations highlight that the instances of initiation of communication increased and motivation to engage with the mobile device and App was high among participants. Prior to the implementation of the App none of the participants utilised P.E.C.S. or their folder to communicate and post intervention 90% of participants were utilising the App to communicate. Thus, it is valid to present a conclusion that the children did use the App more than the folder.

6.1.3 Does a child with ASD communicate more when using a communication app?

The presentation of the results in chapter 5 provides an extensive account of the level of communication engaged in by participants as a whole and also on an individual basis. The evidence provided creates a conclusion that the majority of children with ASD communicate more when using an App. Two participants demonstrated preference to using paper based P.E.C.S. symbols throughout the research; however, access appeared to be a barrier in both cases. It was noted in observations and in stakeholder feedback questionnaires that the intervention was not implemented with the participant as per the implementation plan; thus, potentially impacting upon the child's success. Both of these participants had limited or no access to their mobile device and App; thus, their preference for paper based symbols is inevitable. As stated by Volkmar (2011), the symptomology of ASD supports resistance to change; thus, consistent exposure to a new intervention is key to its success. During observations both of these participants indicated potential in utilising the App for the purpose of communication. Thus, if they received more exposure and access to the App there is a strong possibility that they would have

utilised the mobile device and App to communicate. For those who did utilise the App for the purpose of communication the results were undeniable.

When addressing the question as to whether children with ASD communicate more through an App two aspects are considered; spontaneous communication and verbal abilities. From the experience gained within this research through the utilisation of observations, the increase in verbal abilities can be attributed to the voice output feature within the App. The localisation of the voice output (previous school principal) not only provided the children with familiarity but it also produced vocalisation of words that were dialect appropriate. The concept of increased verbal abilities can also be attributed to the theory of exposure and also to the theory of P.E.C.S. Upon hearing a word consistently some participants began attempting or fully completing verbalisation of that word (Frost and Bondy, 2002). For those participants who were non-verbal, the same principles of exposure applied. Even though they did not verbalise a word, the voice output created consistency and reinforced their request both for them and the communicative partner. This feature in itself provided participants with the confidence to engage in increased instances of communication.

Spontaneous communication is one of the recognised impairments of ASD with the development of spontaneous communication being a rarity amongst children with ASD (Carr and Kologinsky, 1983). The development of spontaneous communication was individual; however, upon completion of the intervention this theme was evident amongst all participants. Participants not only began independently requesting items but some also transitioned to higher P.E.C.S. phases. The theory of exposure is again applicable here with the 'I want' symbol being displayed consistently within the App. The availability of this symbol prompted participants to engage with it consistently; thus, transitioning to phase four of P.E.C.S. The instances of spontaneous communication also increased amongst participants throughout the duration of the intervention.

These increases in communication can also be linked to the themes of motivation to engage and preference to mobile devices and Apps. As outlined by Bernardini et al. (2014), children with ASD show preference to utilising technology as

it is innate within them to be drawn to engage with it; thus, they are motivated by the device and the App to communicate.

In summary, from the evidence presented it is clear that children with ASD engage in increased levels of communication when utilising a communication App. However, their dependency on stakeholders remains with access to their mobile device and App being a concern. A lack of exposure to the App was a rationale for two participants in particular who were evidencing preference for paper based P.E.C.S. symbols. The evidence of their motivation to engage with the App highlights their potential for success if given the support and access to the intervention.

6.1.4 Is the child independent in managing the vocabulary library?

In parallel with the theme of communication, access to the Apps camera feature was restricted by stakeholders. Thus, the results generated within this section are lower than anticipated. The independent use of the camera feature to manage vocabulary was displayed by three participants from the beginning to middle of the intervention. All three participants began independent use upon one demonstration from a stakeholder. As a result of utilising the camera feature within the App it became evident that one participant could spell; no one ever knew this child could spell. This had a significant impact on the child's life as a whole as it increased his independence in the areas of academia and social inclusion. The child's academic routine was tailored to reflect this new learning and he also began utilising the camera feature to initiate social interactions with peers. This prompted the child to become totally independent in managing his vocabulary. The other two participants utilised the camera to develop their vocabulary; however, as their literacy skills were not developed the labelling of new symbols was incorrect. Even though only three participants were independent of their vocabulary they were not the only ones to show potential.

These results indicated in chapter 5 highlight the potential that the other children had to be empowered to independently manage their vocabulary. Campigotto et al. (2013), highlight that this potential is increased with mobile devices due to their simplicity and ease of use. However, one of the potential barriers to

developing this skill may include stakeholder resistance or simply that they may be unsure as to the limits that they can empower the child to act independently. Throughout the duration of this intervention it became clear through observations that participants were not being exposed to the camera feature within the App. Stakeholders were not implementing the plan provided by the researcher in relation to teaching this skill to participants. Therefore, it could not be expected of participants to learn the skill when they were not being exposed or given access to the feature. The results from the evaluation questionnaire triangulate with the researcher's observations and strongly suggest that stakeholders either restricted access or chose not to demonstrate or involve participants in the development of their vocabulary. The management of vocabulary was not the only element evaluated in the area of independence; personal control over their device was also incorporated.

Stakeholder feedback identified that 43% of participants took control over their device with 50% of participants either learning to charge their device independently or requesting assistance with charging. Taking control of their own devices again presents the challenge of access; if a child does not have access to their device they cannot take control of it. Stakeholders as a barrier to access requires exploration particularly when participants displayed interest in their devices. The mobile device and App proved to be a motivation for all participants; thus, a natural progression to controlling their own device was a realistic goal upon completion of the intervention. Researcher observations correlated the lack of access and encouragement for the majority of participants when focusing on independent management of their device.

In summary, three out of ten participants were independent in managing their own vocabulary at the end of the intervention. However, with many participants being introduced to the camera feature on the final observation their potential to learn the skill was observed. Their motivation to engage and preference for the mobile device and App could prove as catalysts to successful independent management of their vocabulary. Empowering participants to take control of their own device occurred amongst under half of the participants; while others were restricted access to their devices and App. In light of the above discussion it could be

argued that stakeholders can act as inhibitors as well as enablers (Derguy et al., 2015). In this case stakeholders were identified as potential barriers to the implementation along with potentially hindering the child's progress. Recommendations to overcome this are presented in chapter 7.

6.1.5 Is the child engaging in behaviours the challenge less frequently?

Chapter 5 indicated that 57% of participants who engaged in behaviours that challenged prior to the intervention experienced decreases post intervention. Not only did the incidents and duration of behaviours that challenge reduce but the development of coping mechanisms occurred. Stakeholder feedback and observations evidenced that the occurrence of behaviour that challenged was less frequent amongst a portion of participants but the length of the behaviour also decreased. It became evident through the analysis of the results that participants who received benefits in this area were those that also had consistent access to their devices and App.

It was also noted that the development of coping mechanisms occurred during either assessment three or four for the identified participants. Participants either began requesting items to aid calming or began engaging in verbal de- escalation techniques as a coping mechanism. As a result of engaging in these coping mechanisms the duration of the behaviour saw a noticeable decline. Participants also used the mobile device and App as a form of coping mechanism. A minority of participants utilised the mobile device and App to redirect their focus and cease engaging in behaviours that challenge. This was an aspect that the researcher did not anticipate; however, it identifies a new dimension that has potential to be implemented within this type of intervention.

In light of these positive occurrences, it is important to note that this type of intervention does not decrease behaviours that challenge as a whole, rather it decreases behaviours that challenge which are in correlation or as a result of impaired communication. As seen with participants 5 and 6, behaviours that challenge manifest with many functions (Bluestone, 2005); sourcing the root of the function is key to the success of implementing interventions to support the person

(Autism Speaks, 2012). Behaviours that challenge are extremely difficult to change; thus, specific interventions are required to target the function. However, implementing these interventions appear lower on the priority list of professionals and parents. This has been attributed to two misconceptions; that the behaviours will subside independently; and that other skills are required, such as, language, to alleviate the presence of behaviours (Leaf and McEachin, 1999). However, teaching language is a complex task which involves time investment and while this is occurring resolving the function of the behaviours is merely delayed. Thus, when evaluating the impact of this intervention on behaviours that challenge it is important to locate these behaviours in context to their function.

In summary, from the evidence presented in chapter 5 and the discussion presented above it is clear that some participants made improvements in the area of behaviours that challenge. Therefore, these participant's behaviours that challenge can be attributed to the having a function of impaired communication. Participants who did not receive improvements within this area may be experiencing behaviours that challenge as a result of other biological or environmental elements. In addressing this question, it is valid to conclude that the use of a communication App resulted in a decrease in behaviours that challenge for over half of participants. Implementing a communication App has proven effective for decreasing behaviours that challenge which hold a function of impaired communication; however, the communication App will not alleviate behaviours associated with other functions.

6.1.6 Is the child engaging more with parents and peers?- social interaction

The evaluation of the engagement with parents, peers and others occurred upon triangulation of the mixed method approach tools that were utilised during the intervention. It is also important to locate social interaction in the context of ASD prior to discussing the results. Social interaction is a rare occurrence among children with ASD and is a key indicator in the diagnosis of ASD (Murray et al., 2014). Therefore, the slightest improvement is worth recognising. The evaluation of improvements within this area is presented in three stems; 1) interaction with parents; 2) interaction with peers or siblings; and 3) interaction with extended family or members of the community.

In light of the barriers to access identified in previous sections and considering the limited use of P.E.C.S. prior to the implementation, the results for social inclusion are encouraging. Forty-two percent of participants initiated engagement with stakeholders through using the mobile device and App which highlights a significant increase. Prior to implementation of the intervention, observations noted that participants did not utilise P.E.C.S.; thus, a 42% increase evidences a significant improvement. This type of improvement was not only evidenced among stakeholders but peers and siblings too.

As outlined by Duffy and Healy (2011), social interaction remains difficult for people with ASD and peer to peer interactions are rare. The symptomology of ASD does not support social interaction; thus, the smallest of gains is positive. The results presented in this research evidence a 29% increase in peer to peer interactions. This figure could be interpreted as being low; however, when put in context with the symptomology of ASD and the profiles of participants prior to the implementation of the intervention the figures are in fact substantial. This is also in parallel with that of the engagement levels with extended family and others.

As discussed in the previous paragraphs, social interaction is an impairment with ASD; thus, interactions with primary carers and peers remains scarce. This is more applicable when exploring interactions with extended family and school staff who are not in direct contact with the child, etc. A child with ASD, in the majority of cases will only interact with these external stakeholders if they are familiar to them. However, this research has evidenced increases within this area.

Again, the figures appear low; however, when located in the context of the symptomology of ASD they show great improvements. This research evidenced, primarily through stakeholder evaluation questionnaires that 21% of participants engaged with external stakeholders while engaging with the mobile device and App. This highlights that those participants are demonstrating the skill of generalisation as per ABA and P.E.C.S. principles. This is a key aspect for the fulfilment of P.E.C.S. guidelines and is key to continuing progress with the remaining phases of P.E.C.S. The evidence of generalisation also encourages the aspect of independence and again highlights its potential for development. If a child has demonstrated generalisation and is interacting with people beyond their immediate circle of support it provides

them with the opportunity to become more independent within their life as a whole. For example, transitioning to a type of independent living in adulthood. The use of generalisation is key to the development of life skills; thus, the utilisation of the App assists with this. Within this research, the interactions with external stakeholders hold the potential to be attributed to the 'coolness' factor of the devices along with utilising the device as a medium to support the social interaction (Campiggotto et al., 2013). The ubiquity of the devices provides external stakeholders with the opportunity to engage with the child's device and App with ease and the child can utilise the device as a support throughout the social interaction.

In summary, this research has provided the case for improved social interaction and inclusion as a result of using a mobile device and App to communicate. This evidence was triangulated through researcher observations and stakeholder evaluation questionnaires. Not only did the participants engage more with parents but as a result of the device and App participants engaged in peer to peer social interactions. This is a rarity that is undeniable and evidences the gains made by participants within this research. The participant's engagements with external stakeholders evidences generalisation of their skills and it also evidences their increase in independence. The improvements received by participants within this area are ones that are difficult and time intensive to teach; thus, the use of a mobile device and communication App holds the potential to assist with this process.

6.1.7 Is the usability of the device suitable for children with ASD?

The decision as to the type of mobile devices that were used within this research was based solely on the needs of the participants. The researcher explored the current use of mobile devices among participants in the stakeholder interviews and it became apparent that participants were familiar, either through home or school, with Apple iPads. The researcher also investigated the needs of participants in relation to visual impairments, fine motor skills, etc. This was completed so as to choose a device that best meet the needs of the participant's. If a participant had difficulties with vision or fine motor skills a larger size screen may have been more appropriate. However, it was evidenced that none of the participants had limitations within these areas. The researcher did evidence during interviews that usability of

the device was key as if there were too many steps required from the child to access the App it could discourage the child from engaging (short attention spans-symptomology).

In light of this, the researcher began exploring different types of mobile devices that held the potential to be most appropriate for participants. After engaging with several devices it became clear that the iPad required the least amount of actions to access the App. As a result of this and keeping in mind the familiarity with participants it was decided that Apple iOS devices would be purchased. As participants did not display limitations in the areas of fine motor skills or visual impairments the iPad mini would suffice for this purpose. The use of this device allowed the researcher to place restrictions for the purpose of the research. For example, the research had implemented a restriction through the settings that would not allow for the participant to delete the App without a password. The purpose of this was to prevent causing the participant undue stress from accidentally deleting their App. The symptomology of ASD does not support unexpected changes; thus, creating this limitation was done so as to ensure the care of the participant. Throughout the duration of the research, the participants did not require training in the functionality of the device and they displayed independent navigation immediately. Thus, it can be concluded that the usability of the iPad mini is suitable for children with ASD.

6.2 Interdisciplinary design

The decision to undertake a research project that focused on interdisciplinary design was made in the development of the research proposal. This decision was made due to the lack of literature available on this topic and also to evidence that collaboration with minority/vulnerable populations and their stakeholders is essential when developing for them. The approach to interdisciplinary design within this research was twofold; up-skilling of the researcher and designing with participants and their stakeholders which incorporated three disciplines; parents, education and SLT. This section begins by discussing the aspect of the researcher up- skilling and then progresses to designing with participants and their stakeholders.

As stated in section 4.3, the researcher up-skilled by learning programming languages that could be used for the development of the App. This up skilling brought with it both strengths and weaknesses. The strengths included: the researchers knowledge and experience in the area of ASD and the researchers access to participants of this profile. The limitations included: restrictions on the functionality of the App. Even though the researcher was restricted in her skillset to develop some features her strengths in the area of ASD outweighed the limitation.

During this intervention the researcher's social care skill set brought advantages in many areas; particularly in the data collection phase through observations. As a result of the researcher's knowledge in ASD the data collected in observations was specific and relative to the research questions. If a computer programmer had been in the same situation there would have been a risk of missing data due to their lack of knowledge and experience within the area. However, as a result of up-skilling in computer science the researcher was given an insight that was crucial for the development of the App. The process of up-skilling allowed the researcher to identify realistic goals for the development of the App which assisted in managing the expectations of stakeholders. If the researcher had not engaged in this process, the ignorance as to the time required to develop specific features could have hindered the research process. Thus, engaging in CPD to up-skill to become an interdisciplinary professional brought a new dimension to the research that allowed for a more fluid collaboration of knowledge between the areas of social science and computer science. Therefore, the decision to adapt an interdisciplinary approach in this research was one that was effective and advisable for other social care professionals with an interest in entering the area of health and social care informatics. However, the interdisciplinary approach when collaborating with stakeholders was one that brought challenges.

The ethos of interdisciplinary collaboration was echoed throughout this research and in particular in the design and development of the App. However, it became clear during interactions with stakeholders that there were two primary concerns: 1) each discipline was fighting for their own corner and 2) the presence of external influences.

During engagement in usability testing with stakeholders the impact of each discipline was evident. The interdisciplinary engagements noted in researcher observations evidenced that each discipline was fighting for their own corner. For example, SLT were more focused on including colour semantics and verbs whereas, each parent was focusing on specific features to benefit their own child. This posed a challenge for the researcher in attempting to focus on the broader picture and develop an App for the participant population and their needs as opposed to focusing on the minority of participants. The second concern was that of external influences which manifested in the influences of existing Apps on the parents.

As presented in Chapter 4, the implementation of suggested user requirements were evaluated based on the needs of the participants, the skill set of the researcher and the evidence in the literature. Again, as a result of delivering the focus group it was evident that stakeholder suggestions were being influenced externally. Other software and Apps were influencing the features they were requesting. For example, when requesting a picture template Boardmaker was mentioned. This is a software used by SLT's when developing symbols for their clients. Other features such as hiding images and adaptability were mentioned in conjunction with highlighting the features of a similar App called iCommunicate. This App was being utilised by a participant at the time for the purpose of vocabulary development as opposed to for the purpose of communication (Evidenced in stakeholder interview). Therefore, the importance of triangulation was demonstrated here as the researcher utilised data collection results along with evidence from the literature and best practice guidelines to develop subsequent iterations of the App (See section 4.5). Thus, it can be said that even though each discipline brings with it its own valuable knowledge and expertise, creating an ethos of designing with the children as opposed to for them remains a challenge for stakeholders. The needs of the overall population of participants required evaluation rather than the desires of each discipline independently.

In light of the concerns, the involvement of stakeholders may need to be re-evaluated in relation to timing. It may be more appropriate and effective to the intervention to involve stakeholders in later stages of the App development. This facilitation may also appeal to stakeholders, especially parents and may assist in

overcoming burnout during the research as outlined in section 3.1. Parents of children with ASD face a continuous uphill battle in relation to accessing services (Oireachtas, 2012); thus, their prioritisation of research may unintentionally be low. Each child has specific needs and with parents facing continuous cuts to services and budgets they may be focusing on securing access to the most immediate service required to meet their child's daily needs. However, the involvement of an interdisciplinary team should not be eliminated. The use of an interdisciplinary team who do not work directly with participants should be involved in the initial stages of development so as to identify preliminary user requirements as a whole rather than focusing on one or a minority of individuals within that population. With these concerns in mind, stakeholders may inevitably become barriers to implementation as opposed to enablers.

6.3 Stakeholders as barriers to implementation

As stated by, Jurgens et al. (2012), the successful implementation of P.E.C.S. is dependent upon the stakeholders of the children with ASD and this research was no different. In order to implement an intervention efficiently and effectively a holistic approach is required. However, it became evident throughout the implementation of the intervention that stakeholders were presenting as a barrier rather than an enabler of the research. As a result of the fact that participant and stakeholder involvement in this research was voluntary and stakeholders were aware that they could cease involvement at any time the case for stakeholders being unintentional barriers could be made.

As this is a new area of research, particularly in Ireland, stakeholders may have been apprehensive or resistant to adapt their current metaphor to one that was more high tech. Even though the researcher provided stakeholders with an information session and outlined the evidence behind the intervention some stakeholders may have required extra training in this area. Additional training in the area of assistive technology and in particular about the use of mobile devices and Apps could provide the stakeholder with a sense of greater competency when implementing the intervention (Jurgens et al., 2012). From the evidence gathered

during observations it appeared that some stakeholders were apprehensive about using the mobile device and App as they feared the devices would be damaged. A lack of knowledge and support in the area of assistive technology for stakeholders presents as one of the barriers that manifests into stakeholders becoming inhibitors to an intervention.

A stakeholders' lack of knowledge as to the potential that their role holds for empowering children to act independently also presented as a barrier to the implementation of the intervention. Stakeholders appear to underestimate the impact that they could potentially have on a child's independence. This was particularly evident when stakeholders chose not to expose participants to the camera feature within the App. Instead of teaching the skill and supporting the children to become independent in managing their own vocabulary stakeholders either engaged with the vocabulary available within the App only or took images for the children. Even when developing the children's vocabularies for them stakeholders did not encourage or include participants in the task. Exposure to the feature alone would have created familiarity amongst participants with the hopes that they would transition to independently managing their vocabulary with time. However, this did not appear to be a priority for stakeholders; even though the literature (Flippin, Reska and Watson, 2011) and data collected during interviews highlights that stakeholders view the development of paper P.E.C.S. vocabulary as time intensive. This research provided stakeholders with the opportunity to eliminate the task of developing P.E.C.S. symbols; however, this desire was not demonstrated during observations upon implementation of the intervention. Thus, stakeholders instead of being active enablers in creating independence among participants became inhibitors to the implementation of the intervention. Stakeholders are primary influencers for children; thus, their active engagement is essential for a child to make progress.

6.4 Chapter Summary

In conclusion, this chapter presents a discussion in relation to answering the initial six research questions as set out at the beginning of the research. However,

throughout the duration of the research these six questions evolved to create greater depth and breadth providing information within this area that had not been foreseen. Three of the primary areas that evolved during this research were: 1) the potential to overcome the limitations of P.E.C.S. through the use of a mobile device and communication App; 2) the impact that an interdisciplinary approach can have on the development of health and social care informatics Apps and 3) the development of stakeholders as barriers to implementation. The initial aim of the research was to investigate if a communication App could enhance the P.E.C.S. process for the individual. The research not only proved this effective but it proved that the P.E.C.S. process as a whole was enhanced. The adoption of an interdisciplinary approach resulted in the development of an App that was end-user focused targeted a sample of the population as opposed to developing for one individual. This approach is not without its limitations; however, the benefits that it brings improves upon the current routes of development for these types of Apps. The development of stakeholders as barriers to implementation was one that was not anticipated; however, it appeared to be unintentional with the lack of knowledge and support in the area being attributing factors.

Chapter 7: Conclusions and Recommendations

7.0 Dissertation Conclusion

Chapter 7 aims to conclude the dissertation by providing a brief summary of the findings with reference to the research questions along with providing recommendations for research going forward. The researcher kept a personal reflective journal throughout the duration of the research with the ideology of reflecting upon it when writing this chapter. These reflections were particularly important for the development of recommendations for future research. This chapter begins by summarising briefly the results with respect to the research questions.

As previously stated, there were six primary research questions that were posed at the beginning of this research. This research set out to answer these questions while taking a multi-disciplinary approach. The completion of the research evidenced that this intervention was effective in at least one area, for all participants with respect to making improvements in the communication, social inclusion, independence, attention span and behaviours that challenge.

From the evidence presented in this dissertation it is clear that participants made gains in the area of communication. The research evidenced that the participants utilised the P.E.C.S. App more than their P.E.C.S. folders; with some participants never having a P.E.C.S. folder. The results also evidenced that within the area of communication, participants received benefits in relation to increased instances of initiating communication and motivation to communicate. Over half of participants experienced increased sentence structure which can be attributed to exposure and modelling by stakeholders. Therefore, it is accurate to conclude that children with ASD communicated more when utilising the communication App.

The concept of independent management of vocabulary is one that created controversy from the outset of the research. It was clear from the beginning that stakeholders wanted complete control over the camera feature in order to add new symbols as opposed to teaching the children how to engage in the process. Thus, as

a result of restricted access the majority did not master this skill. Approximately one third of participants were independently managing their vocabulary while over half of the remaining participants demonstrated potential to learn the skill. Thus, in light of this, stakeholder feedback evidenced that approximately 80% of participants had mastered or had the potential to master the skill of independent management of their vocabulary.

One of the key findings that emerged from this research was in relation to behaviours that challenge. It was clear from chapter two that the literature was evidencing significant improvements within children with ASD who utilised a mobile device and communication App. However, it became evident during this research that participants who displayed improvements were those whose behaviours were as a result of impaired communication. The incidents and duration of these behaviours that challenge did decrease for the children; however, identifying the function of the behaviour was essential. One participant in particular evidenced this theory as the function of his behaviours that challenged were not as a result of impaired communication; thus, the use of the device and App had no impact on his behaviours. Even though this participant did not receive benefits others who experienced behaviours that challenged evidenced improvements within this area.

The concept of social inclusion remains difficult for children with ASD; however, this research evidenced that there were instances of not only child to parent/staff interactions but also peer to peer interactions and peer assisted learning. As previously outlined, these are rare occurrences among children with ASD and particularly within special needs classrooms. Therefore, it is valid to state that there was an increase in social inclusion amongst the majority of participants.

The usability of the devices was a concern in the initial stages of the research. However, upon exploration of the topic it was evidenced that the iPad would be most suitable for the children based on the usability evaluation and familiarity of the device among participants. The usability testing sessions at the beginning of the implementation of the intervention evidenced that all participants had the ability to navigate the device in order to access the App. Therefore, the usability of the iPad mini was suitable for children with ASD.

In light of analysing the results and discussions presented there are three key points that are particularly significant for this research; effectiveness of P.E.C.S., stakeholders and their involvement.

As a result of the evidence presented throughout this dissertation it is clear that the utilisation of a communication App increases effectiveness and efficiency of the P.E.C.S. metaphor. Children with ASD were more empowered to take control and create their own voice as opposed to being dependent upon stakeholders. Drawing on the analysis completed in chapter five, the effectiveness of this intervention is clear. Chapter five provided an extensive account of participant's progress throughout the research; however, it is important to recognise some of the positives of the technology used. The use of a communication App proved effective for these children with ASD in the areas of communication, social inclusion, independence, attention span and behaviours that challenge. The children had not previously been exposed to these benefits through the use of traditional P.E.C.S.; thus, the introduction of this intervention enhanced the user experience when engaging with P.E.C.S. With that in mind, it is also important to highlight that even though this App enhanced the lives of the children it holds similar limitations to traditional P.E.C.S. It became evident throughout the research that children were solely dependent on stakeholders to teach them the process of P.E.C.S. effectively; however, stakeholders had little or no training or experience in doing so. Again, this reiterates the point that the App is a tool and not the cure. There are many Apps available that incorporate the metaphor of P.E.C.S.; however, the recommendation of follow on Apps for participants is an individualised service. Some of the Apps that are on the market include: Proloquo2Go, TaptoTalk, JABtalk, AAC Communicator, etc.

The second and third points refer to stakeholders and their involvement. The second point focuses on adapting a multi- disciplinary approach to the development of AAC technologies. This approach has proven essential for the development of an App that was end-user focused; however, the point of time that stakeholders become involved requires evaluation. It was clear throughout the intervention that stakeholders were experiencing burnout due to the longitudinal approach to the development of the App. The third and final point focuses on the importance of stakeholders to ensure an intervention is successful. As previously highlighted in this

dissertation stakeholders can become inhibitors of an intervention; thus, receiving buy-in from them along with receiving their continued support are aspects that are crucial to the success of an intervention for their children. As outlined earlier in the dissertation, there are limitations to every piece of research. Without revisiting these points in detail; there are three main limitations to this research project. Firstly, it is important to continue to recognise that an App is not a cure and it will not solve all of a child's limitations or difficulties; it is simply a tool. The App requires time investment while adopting a multi-disciplinary approach in order to enrich the potential benefits for the user. Therefore, an App is only as effective as the team (child, parents and other stakeholders) that are utilising it. Secondly, receiving buy-in from stakeholders is key for a successful intervention. If stakeholders do not see the value that the App can bring the intervention runs the risk of becoming abandoned. Stakeholder buy-in provides motivation for stakeholders to continue with the intervention, implement It as recommended and provide consistency with use. In turn, the child is more exposed to receiving the potential benefits of the App. Finally, even though this was an extensive research project the duration of evaluating the effectiveness of the App was based on a twelve week period. This is a small snap shot of the lives of these children; thus, given the opportunity there is potential for this research to be implemented for a longer period of time. An extended period of evaluation would offer insight into how the App would effect the child and for how long. Receiving immediate positive results proves the concept of the use of communication Apps; however, evaluating how long these effects last is key for future communication interventions with children with ASD.

Not withstanding the limitations of this research, there were positives and keeping with the UCD approach it is important to highlight some comments made by stakeholders. The incorporation of end user and stakeholder feedback provided an enriched data collection process. Throughout the duration of the research, stakeholders gave feedback to the researcher on the progress of the App. Stakeholders made comments such as; 'he loves his independence'; 'he has learned how and when to charge his iPad'; and 'he is getting new words every day, he is talking mad since he came back [from mid-term bread]'. As previously stated, the majority of participants were non-verbal; thus, P.E.C.S. was utilised throughout to gain their feedback. Those

participants who decided they would like to give feedback stated using P.E.C.S. that they like the App; with one participant verbalising 'yes App'.

Due to the recommendation of future communication Apps being an individualised service, all participants were offered a free consultation with the researcher to identify a suitable App that would aid their progress. Going forward, there is a clear need to create awareness around the use of Apps for stakeholders in order to ensure that future interventions like these are successful and that stakeholders do not develop to be a barrier to success. User Centred Design is not always the easiest method to take for research and development. It requires the researcher to be patient, innovative, inventive and passionate; but it is the righ thing to do. The interdisciplinary approach within this research was key to its success and it highly recommended for future interventions. This research was interdisciplinary from the outset with the development of the research team and this was continued on throughout the duration of the research through liaising with parents, teachers, speech and language therapists and most importantly, the children.

In conclusion, this dissertation has proffered evidence and argued that the use of a communication App and mobile device with children with ASD is effective for their communication, social inclusion, independence, attention span and behaviours that challenge. This dissertation also outlines the importance of engaging in this process while adopting a multi-disciplinary approach. The consideration of a multi-disciplinary approach brought about the development of an App that not only met the needs of end users but was also based on empirical evidence. The collaboration of disciplines was an essential aspect in the development of an App which aimed to collect user requirements of greater depth and breadth through the use of action research and user centred design.

7.1 Recommendations

On foot of the results generated and the conclusions drawn from this study, the researcher proposes five recommendations for consideration in further research

within this area. The five recommendations that were developed as a result of completing this research are:

1. Future multi-disciplinary approaches: This recommendation is twofold; a) up-skilling of social care professionals and b) the utilisation of current tools. The researcher is recommending that any social care professional who decides to enter the sector of health and social care informatics first learns the language of computer science. This was a crucial aspect for the researcher throughout the research and is highly recommended. However, on foot of this the researcher recommends that the social care professional then collaborates with an App developer in order to develop the prototypes. The App developer can provide the social care professional with the expertise to implement more sophisticated features within the App, for example, adding voice output recordings to personalized symbols. The social care professional would have the ability to engage in the majority of the UCD framework upon completion of the CPD process; however, in order to maximise time and resources it would be most effective to collaborate with professionals from computer science to develop the logistics of the App. It was highlighted in this dissertation about the level of difficulty encountered when utilising tools such as PhoneGap; however, technology is a rapidly developing area and these tools are improved upon consistently. Therefore, it is the recommendation that health and social care informatics professionals do not solely rely on these tools but they do consider them in the future for the development of prototypes etc.
2. Training: The need for formal and accessible training for stakeholders was a key theme that was noted throughout this dissertation. The recommendation for training is in relation to both P.E.C.S. and mobile devices. Phased training modules may prove more effective for stakeholders as opposed to attempting to attend a full two day workshop that presents with barriers to entry as discussed earlier in this dissertation. However, it is also important to highlight that the availability of this training must be matched with commitment and support from stakeholders in order for it to be effective.

3. Evidenced based approach to assessing mobile devices and Apps: It became clear during this research that professionals are currently recommending mobile devices and Apps based on ad-hoc information. Meeting the needs of the individual is of upmost importance when implementing an intervention; thus, it is more effective to match an App/mobile device to a person as opposed to attempting to 'fit' the person to the App/mobile device. Thus, the need for professionals to adapt an evidenced based approach to assessing people with disabilities for the use of mobile devices and App is essential for the success of future interventions within this area.
4. Department of Education and skills: There is a need for the DOE to provide hands-on support to schools and individuals who utilise these types of technologies. There is also a need for the DOE to provide support for schools when accessing training in A.T. Professionals appear to be faced with barriers to access when attempting to attend training courses (discussed in section 2.6.2).
5. Policy recommendation: The current A.T. policy in Ireland outlines strict guidelines as to the qualification for a grant to purchase A.T. for a person with a disability. This policy is also restrictive in stating that a person must be otherwise unable to participate in education without the device. Even though a person can technically participate the extent of this participation must be evaluated. It is also a recommendation that the wording of the policy be adapted to remove this along with the exclusion of Smartphones and iPods. Research is showing that it is not only Tablets/iPads that are effective A.T. tools but Smartphones and iPods are proving similar efficacy. The need to include evidenced based assessments by a professional specifically qualified in this area is essential in order to implement interventions that are effective. It is also recommended that a duly qualified professional oversee the implementation of the intervention and provide progress reports accordingly.

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Appendices

Appendix A: Health Information Quality Authority (HIQA) Standards for Assessment of Need

Extracts from the full document:

Standard	Criteria
Person Centred Approach	1. Assessments of Need are conducted without regard to the cost of, or capacity to provide, any service identified in the Assessment of Need, 2. The person is fully informed throughout the Assessment of Need, 3. The person is entitled to actively participate in the Assessment of Need, 4. The person's contribution to the Assessment of Need is central, 5. The person's privacy with regard to environment and information is respected and safeguarded, 6. The Assessment of Need report is a comprehensive, evidence based, up to date and accurate record of the findings of the person's Assessment of Need, 7. The person is informed of the complaints/appeals process and of his/her entitlements to make a complaint/appeal.
Information	1. Information regarding the Assessment of Need process is widely distributed, clearly stated and readily available in a range of accessible formats, 2. Policies and Procedures governing the Assessment of Need process are made known to and followed by staff and communicated to participating persons, 3. All information and records gathered during the Assessment of Needs are held in a secure manner and all information is held and dealt with in confidence, 4. Complaints and appeals in relation to the Assessment of Need are dealt with in accordance with legislation
Access to the *Assessment of Need*	1. The application process is simple, efficient and accessible, 2. Applications are dealt with in a prompt and efficient manner, 3. The *Assessment of Need* is conducted in an environment that is safe and accessible to the person
Involving Appropriate Education and Health Staff	1. Child and adult protection, 2. Staff are suitably qualified, *3.* Induction, training and supervision of staff carrying out the *Assessment of Need,* 4. Equality and diversity is promoted and valued among staff, 5. Assessments of Need are conducted in a consistent manner nationally, 6. Continuity in Assessment of Need.

Coordination of the *Assessment of Need*	1. The Assessment Co-ordinator ensures that all aspects of the *Assessment of Need* process are effectively coordinated, 2. The Assessment Co-ordinator ensures that where a number of professionals are involved in the *Assessment of Need*, they work in a co-ordinated way, 3. Effective links with other services
Monitoring and Review	1. The implementation of the standards is monitored by HIQA in accordance with legislation, 2. Providers of *Assessments of Need* are obliged to comply with these standards and conduct regular evaluations, 3. The standards are reviewed and up-dated on a regular basis by HIQA in accordance with legislation

Appendix B: DSM-5 ASD Diagnostic Criteria

Social (Pragmatic) Communication Disorder 315.39 (F80.89)

Diagnostic Criteria

A. Persistent difficulties in the social use of verbal and nonverbal communication as manifested by all of the following:

1. Deficits in using communication for social purposes, such as greeting and sharing information, in a manner that is appropriate for the social context.

2. Impairment of the ability to change communication to match context or the needs of the listener, such as speaking differently in a classroom than on the playground, talking differently to a child than to an adult, and avoiding use of overly formal language.

3. Difficulties following rules for conversation and storytelling, such as taking turns in conversation, rephrasing when misunderstood, and knowing how to use verbal and nonverbal signals to regulate interaction.

4. Difficulties understanding what is not explicitly stated (e.g., making inferences) and nonliteral or ambiguous meanings of language (e.g., idioms, humor, metaphors, multiple meanings that depend on the context for interpretation).

B. The deficits result in functional limitations in effective communication, social participation, social relationships, academic achievement, or occupational performance, individually or in combination.

C. The onset of the symptoms is in the early developmental period (but deficits may not become fully manifest until social communication demands exceed limited capacities).

D. The symptoms are not attributable to another medical or neurological condition or to low abilities in the domains or word structure and grammar, and are not better explained by autism spectrum disorder, intellectual disability (intellectual developmental disorder), global developmental delay, or another mental disorder.

Autism Spectrum Disorder 299.00 (F84.0)

Diagnostic Criteria

A. Persistent deficits in social communication and social interaction across multiple contexts, as manifested by the following, currently or by history (examples are illustrative, not exhaustive, see text):

1. Deficits in social-emotional reciprocity, ranging, for example, from abnormal social approach and failure of normal back-and-forth conversation; to reduced sharing of interests, emotions, or affect; to failure to initiate or respond to social interactions.

2. Deficits in nonverbal communicative behaviors used for social interaction, ranging, for example, from poorly integrated verbal and nonverbal

communication; to abnormalities in eye contact and body language or deficits in understanding and use of gestures; to a total lack of facial expressions and nonverbal communication.

3. Deficits in developing, maintaining, and understanding relationships, ranging, for example, from difficulties adjusting behavior to suit various social contexts; to difficulties in sharing imaginative play or in making friends; to absence of interest in peers.

Specify current severity:

Severity is based on social communication impairments and restricted repetitive patterns of behavior (see Table 2).

B. Restricted, repetitive patterns of behavior, interests, or activities, as manifested by at least two of the following, currently or by history (examples are illustrative, not exhaustive; see text):

1. Stereotyped or repetitive motor movements, use of objects, or speech (e.g., simple motor stereotypies, lining up toys or flipping objects, echolalia, idiosyncratic phrases).

2. Insistence on sameness, inflexible adherence to routines, or ritualized patterns or verbal nonverbal behavior (e.g., extreme distress at small changes, difficulties with transitions, rigid thinking patterns, greeting rituals, need to take same route or eat food every day).

3. Highly restricted, fixated interests that are abnormal in intensity or focus (e.g, strong attachment to or preoccupation with unusual objects, excessively circumscribed or perseverative interest).

4. Hyper- or hyporeactivity to sensory input or unusual interests in sensory aspects of the environment (e.g., apparent indifference to pain/temperature, adverse response to specific sounds or textures, excessive smelling or touching of objects, visual fascination with lights or movement).

Specify current severity:

Severity is based on social communication impairments and restricted, repetitive patterns of behavior (see Table 2).

C. Symptoms must be present in the early developmental period (but may not become fully manifest until social demands exceed limited capacities, or may be masked by learned strategies in later life).

D. Symptoms cause clinically significant impairment in social, occupational, or other important areas of current functioning.

E. These disturbances are not better explained by intellectual disability (intellectual developmental disorder) or global developmental delay. Intellectual disability and autism spectrum disorder frequently co-occur; to make comorbid diagnoses of autism spectrum disorder and intellectual disability, social communication should be below that expected for general developmental level.

Note: Individuals with a well-established DSM-IV diagnosis of autistic disorder, Asperger's disorder, or pervasive developmental disorder not otherwise specified should be given the diagnosis of autism spectrum disorder. Individuals who have marked deficits in social communication, but whose symptoms do not otherwise meet criteria for autism spectrum disorder, should be evaluated for social (pragmatic) communication disorder.

Specify if:

With or without accompanying intellectual impairment

With or without accompanying language impairment

Associated with a known medical or genetic condition or environmental factor
(**Coding note:** Use additional code to identify the associated medical or genetic condition.)

Associated with another neurodevelopmental, mental, or behavioral disorder
(**Coding note:** Use additional code[s] to identify the associated neurodevelopmental, mental, or behavioral disorder[s].)

With catatonia (refer to the criteria for catatonia associated with another mental disorder, pp. 119-120, for definition) (**Coding note:** Use additional code 293.89 [F06.1] catatonia associated with autism spectrum disorder to indicate the presence of the comorbid catatonia.)

Table 2 Severity levels for autism spectrum disorder

Severity level	**Social communication**	**Restricted, repetitive behaviors**
Level 3 "Requiring very substantial support"	Severe deficits in verbal and nonverbal social communication skills cause severe impairments in functioning, very limited initiation of social interactions, and minimal response to social overtures from others. For example, a person with few words of intelligible speech who rarely initiates interaction and, when he or she does, makes unusual approaches to meet needs only and responds to only very direct social approaches	Inflexibility of behavior, extreme difficulty coping with change, or other restricted/repetitive behaviors markedly interfere with functioning in all spheres. Great distress/difficulty changing focus or action.
Level 2 "Requiring substantial support"	Marked deficits in verbal and nonverbal social communication skills; social impairments apparent even with supports in place; limited initiation of social interactions; and reduced or abnormal responses to social overtures from others. For example, a person who speaks simple sentences, whose interaction is limited to narrow special interests, and how has markedly odd nonverbal communication.	Inflexibility of behavior, difficulty coping with change, or other restricted/repetitive behaviors appear frequently enough to be obvious to the casual observer and interfere with functioning in a variety of contexts. Distress and/or difficulty changing focus or action.

Level 1 "Requiring support"	Without supports in place, deficits in social communication cause noticeable impairments. Difficulty initiating social interactions, and clear examples of atypical or unsuccessful response to social overtures of others. May appear to have decreased interest in social interactions. For example, a person who is able to speak in full sentences and engages in communication but whose to- and-fro conversation with others fails, and whose attempts to make friends are odd and typically unsuccessful.	I Inflexibility of behavior causes significant interference with functioning in one or more contexts. Difficulty switching between activities. Problems of organization and planning hamper independence.

Appendix C: Systematic Review on the Effectiveness of the Picture Exchange Communication System (P.E.C.S.)

Year	Author	Theme
2015	Battaglia and McDonald	Increased communication Decreased behaviours
2012	Carson et al	Increased verbalisation Increased requests
2012	Anderson and Moore	Increased verbalisation Decrease in behaviours Importance of accurate implementation of P.E.C.S. strategies Need for parent education for implementing P.E.C.S.
2011	Flippin, Reska and Watson	Increased requesting Increased exchange Increased initiations
2010	Dogoe, Banda and Lock	Increased requesting
2010	Travis and Geiger	Increased requesting Increased commenting Increased sentence length Increased verbalisation
2009	Ganz, Parker and Benson	Increased requesting Increased verbalisation
2009	Jurgens, Anderson and Moore	Increased requesting Increased verbalisation Increased sentence length Increased initiation
2007	Howlin, Wade and Charman	Increase in requesting Increase in verbalisation Importance of teacher training, consultation and monitoring in the implementation of P.E.C.S.
2006	Yoder and Stone	Increased requesting
2006	Marckel, Neef and Ferrei	Increased requesting

2004	Ganz and Simpson	Increased verbalisation
2003	Magiati and Howlin	Increase vocabulary Increased frequency of use Increased spontaneous communication Increased verbalisation Decreased behaviours Requirement for stakeholder P.E.C.S. training
2002	Charlop-Christy, Carpenter, Le, LeBlanc and Kellet	Decreased behaviours Increased verbalisation
2002	Kravits et al.	Increased verbalisation Increased spontaneous communication
2001	Frea, Arnold and Vittemberga	Decreased behaviours
2000	Webb	Increased vocabulary Increased verbalisation
1998	Schwartz, Garfinkle and Bauer	Increased spontaneous communication
1994	Bondy and Frost	Increased verbalisation

Appendix D: Step by Step Guide to creating a P.E.C.S. Book

Materials required:

- Folder (ring binder),
- Velcro,
- Laminator,
- Laminating sheets,
- Coloured sheets,
- Hole puncher
- Person-Centred vocabulary cut into individual symbols*

Step 1:
Laminate one coloured sheet per identified category (e.g. red for food, blue for activities, green for clothes). Punch holes close to the edge of each page to facilitate incorporation into the folder.

Step 2:
Attach strips of velcro to the laminated coloured sheet.

Step 3:
Laminate the individual symbols. Leave them to cool. Cut them out into individual symbols.

Step 4:
Attach the opposite side of the Velcro to the symbol (ensure it sticks to the Velcro attached to the category page).

Step 5:
Cut one long piece of coloured paper (for the sentence strip), laminate it and Velcro it to the folder as seen below.

Step 6:
Insert vocabulary into each category and insert category into the folder.

Step 7:
Create a minimum of two extra symbol sets in order to ensure immediate access if/when symbols get lost.

*Sourcing symbol sets is individual for each child. Identifying a symbol set takes time and some come with a cost; thus, the time taken to complete this task is underestimated. The development of symbols is also underestimated as depending on the symbol set chosen a required word may not be available within the chosen set and may need to be sourced elsewhere.

Appendix E: Review of the benefits of communication Apps and mobile devices

Year	Author	Title
2015	Virnes et al.	Review of research on children with Autism Spectrum Disorder and the use of technology
2014	Sigafoos et al.	Augmentative and Alternative Communication for Individuals with Autism Spectrum Disorder and Intellectual Disability
2014	McEwen	Mediating sociality: the use of iPod Touch devices in the classrooms of students with autism in Canada
2014	Alzrayer et al.	Use of iPad/iPods with individual with Autism and other developmental disabilities: a meta-analysis of communication interventions
2014	King et al.	iPad use in children and young adults with Autism Spectrum Disorder: An observational study
2013	Ganz et al.	Effectiveness of the PECS Phase III App and choices between the App and traditional PECS among pre-schoolers with ASD
2013	Campigotto et al.	Especially social: exploring the use of an iOS application in special needs classrooms
2013	Bradshaw	The use of Augmentative and Alternative Communication apps for the iPad, iPod and iPhone: An overview of recent developments
2013	McNaughton and Light	The iPad and Mobile Technology Revolution: Benefits and Challenges for Individuals who

		require Augmentative and Alternative Communication
2011	Thunberg	Augmentative and Alternative Communication Intervention for children with Autism Spectrum Disorders
2011	Walker	Evaluating the effectiveness of Apps for mobile devices
2010	Kagohara et al.	Behavioural intervention promotes successful use of an iPod-based communication device by an adolescent with autism
2010	De Leo et al.	A Smart-Phone Application and a Companion Website for the Improvement of the Communication Skills of Children with Autism: Clinical Rationale
2009	Sennott and Bowker	Autism, AAC and Proloquo2Go
2008	Marks and Milne	iPod Therefor I can: enhancing the learning of children with intellectual disabilities through emerging technologies

Appendix F: Stages of Language Acquisition

Here are the stages of child language development. As you look at the stages, remember that children develop at different rates.

Stage	Typical age	Examples
Pre-talking stage At birth, the infant vocal tract is in some ways more like that of an ape than that of an adult human. In particular, the tip of the velum reaches or overlaps with the tip of the epiglottis. As the infant grows, the tract gradually reshapes itself in the adult pattern. Are children born with a blank slate? No. Nursing studies show that babies respond to the human voice and especially to speech sounds. During the first two months of life, infant vocalizations are mainly expressions of discomfort (crying and fussing), along with sounds produced as a by-product of reflexive or vegetative actions such as coughing, sucking, swallowing and burping. During the period from about 2-4 months, infants begin making "comfort sounds", typically in response to pleasurable interaction with a caregiver. The earliest comfort sounds may be grunts or sighs, with later versions being more vowel-like "coos". Laughter appears around 4 months.	0 - 6 months	View: • Baby Natalie interacting with her grandma (who speaks Chinese) (YouTube)
Babbling stage During the period from 4-7 months, infants typically engage in vocal play, manipulating pitch (to produce "squeals" and "growls"), loudness (producing "yells"), and also manipulating tract closures to produce friction noises, nasal murmurs, "raspberries" and "snorts". At about seven months, babbling appears: infants start to make extended sounds that are chopped up rhythmically by oral articulations into syllable-like sequences, opening and closing their jaws, lips and tongue. Repeated consonant+vowel sequences are often produced, such as [bababa] or [nanana]. Both vocal play and babbling are produced more often in interactions with caregivers,	6-8 months	View: • Babbling baby on tummyand Babbling baby in pink(YouTube) • Baby babbling "talking" on a phone, from Metacafe)

but infants will also produce them when they are alone. These vocalizations are vowel-like sounds, pitch, and intonation contours that resemble adult contours. No other animal does anything like babbling. It has often been hypothesized that vocal play and babbling have the function of "practicing" speech-like gestures, helping the infant to gain control of the motor systems involved, and to learn the acoustical consequences of different gestures.		
Holophrastic stage One multipurpose word often usually used to convey the child's needs and world views. At about ten months, infants start to utter recognizable words. Some word-like vocalizations that do not correlate well with words in the local language may consistently be used by particular infants to express particular emotional states. For the most part, recognizable words are used in a context that seems to involve one of three functions (the examples are from my daughter, Kalikolehua, when she was about 9 months old): 1. linked with a child's own action or desire for action: "Down" (she no longer wants to be carried) "Kaukau?" (she is hungry and wants something to eat) 2. used to convey emotion: "Auwi" (she hurt herself) "No!" (she doesn't want to do what is being requested) 3. serve a naming function: "Koko" (she identifies herself in a mirror) Young children often use words in ways that are too narrow, called underextensions ("bottle" used only for plastic bottles; "teddy" used only for a particular bear) or too broad, calledoverextensions ("dog" used for lambs, cats, and cows as well as dogs; "kick" used for pushing and for wing-flapping as well as for kicking.) These underextensions and overextensions develop and change over time in an individual child's usage.	9-18 months	Examples: • "Cookie" (means "May I have a cookie?" • "Up!" (means "Carry me please") • "Doggie" (means "I see the dog.") • "Duck" (while the child hits a toy duck in the bath • "Papa" when the child hears the doorbell.
Two-word stage	18-24 months	"mini-sentences" with simple semantic relations

There is often a spurt of vocabulary acquisition during the second year. Early words are acquired at a rate of 1-3 per week (as measured by production diaries); in many cases the rate may suddenly increase to 8-10 new words per week, after 40 or so words have been learned. However, some children show a more steady rate of acquisition during these early stages. The rate of vocabulary acquisition definitely does accelerate in the third year and beyond: a plausible estimate would be an average of 10 words a day during pre-school and elementary school years. During the second year, word combinations begin to appear. Novel combinations (where we can be sure that the result is not being treated as a single word) appear sporadically as early as 14 months. At 18 months, 11% of parents say that their child is often combining words, and 46% say that he or she is sometimes combining words. By 25 months, almost all children are sometimes combining words, but about 20% are still not doing so often.		Examples: • "Mommy work" (when asked "Where's mommy?", means "Mommy's at work now" • "Go bye-bye" (child watching dog walk out the back door, means "The dog is going outside." View: • "Oh Yeah, Baby." Aunty Crystal is a bit annoying, but notice how the child is able to follow her aunt's commands and can form understandable words. (YouTube)
Telegraphic stage or early multiword stage The child is still mostly understood by his/her parents and caregivers. "Telegraphic" sentence structures are *lexical*rather than *functional* or *grammatical*morphemes. In the early multi-word stage, children who are asked to repeat sentences may simply leave out the determiners, modals and verbal auxiliaries, verbal inflections, etc., and often pronouns as well. The same pattern can be seen in their own spontaneous utterances. At about the age of two, children first begin to use grammatical elements. In English, this includes finite auxiliaries ("is", "was"), verbal tense and agreement affixes ("-ed" and '-s'), nominative pronouns ("I", "she"), complementizers ("that", "where"), and determiners ("the", "a"). The process is usually a somewhat gradual one, in which the more telegraphic patterns alternate with adult or adult-like forms. Over a year to a year and a half, sentences get longer, grammatical elements are less	24-30 months	View: • Child talking on the phone to Barney(YouTube) • Toddler watching herself on TV (YouTube) • Repeating Toddler. Notice how the child has mastered many individual sounds but runs into trouble when many sounds are combined into syllables. Comprehension is not an issue here. He understands what he's being asked to do. He is able to inflect his sentences. (YouTube) • Baby talking Spanglish(YouTube) such as "Policeman in agua"

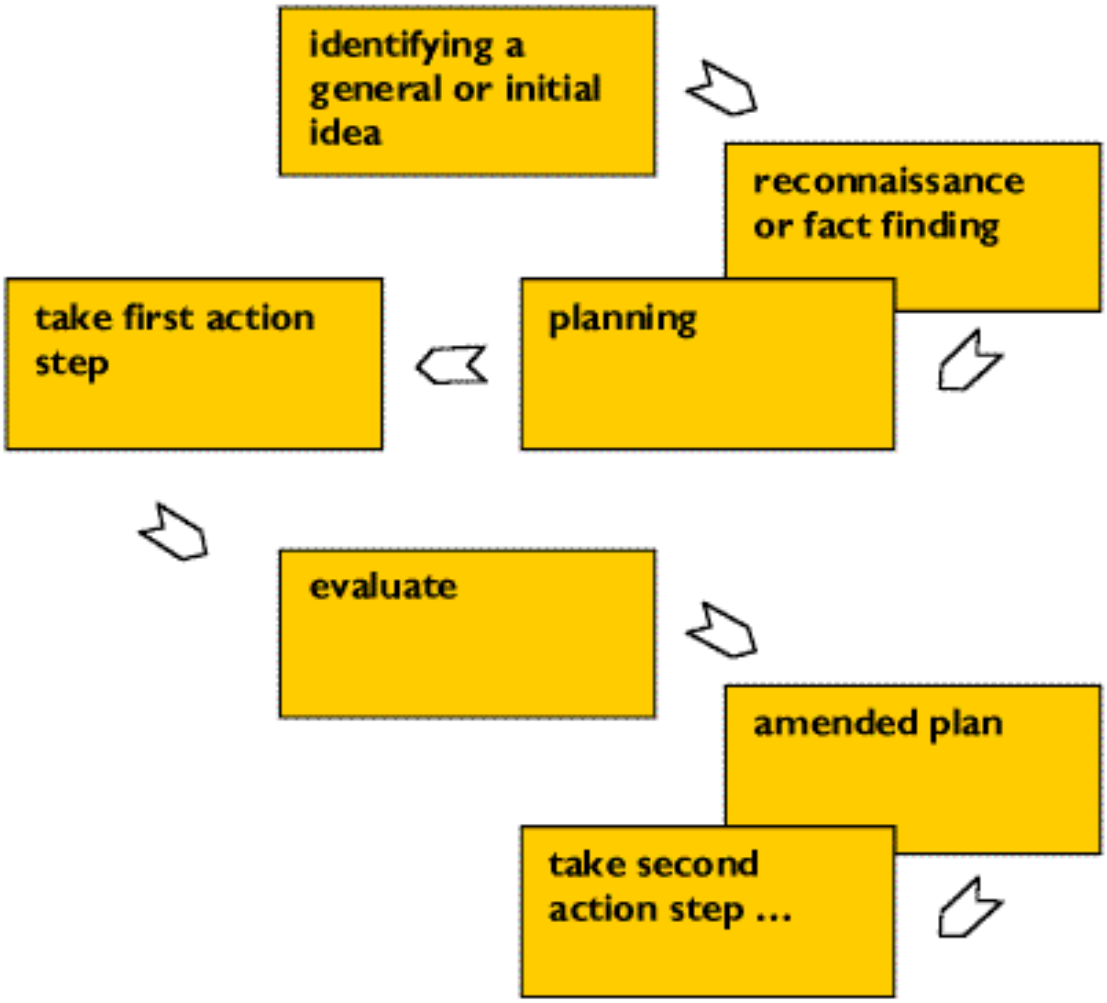
often omitted and less often inserted incorrectly, and multiple-clause sentences become commoner.		
Later multiword stage By age 5, utterances average 4.6 words per sentence and vocabulary increases by about 20 words per day. By age 6, the child knows about 13,000 words. By age 8, the child knows about 28,300 words.	30+ months	*Grammatical* or *functional*structures emerge

Appendix G: Department of Education Assistive Technology Policy

Extract from the policy:

1. For children with physical or severe communication disabilities: laptop/tablet computers with associated modified software, joysticks, keyboards, touch pads, where it has been outlined that the equipment is essential to access the curriculum.
2. The following equipment is not provided for under this scheme: 1. Telephones/Smart phones, iphones, ipods, televisions, furniture and fittings, plasma screen TVs, internet access or phone connectivity charges. 2. Communication devices or medical or therapy related devices which are not specific educational interventions, or equipment specifically required as essential for school educational access, and which have a general application outside of school, which are normally provided for children with disabilities by the Health Service Executive (HSE) and which are provided for through the HSE Aids and Appliances scheme are not provided for under this scheme.
3. Applications for equipment will be considered on the basis of the following criteria: • That the professional who assesses the child has made a recommendation that assistive technology is essential for the effective education of the child, including illustrating how the equipment will be used. (An assessment indicating that equipment would be beneficial, desirable, useful or would achieve improvement in performance will not be sufficient since this could be true in the case of any child.) • Other than in respect of children in category A above, schools will be required to show that they have engaged in sustained efforts to meet the identified needs of the child through appropriate interventions eg teaching the necessary skills, putting in place appropriate accommodations (as evidenced in IEPs), including utilising the school's current information technology provision. • That the case is made or that evidence is supplied that demonstrates that the child will need the recommended equipment throughout the school day. (Some children may, for example, require the use of a computer only for a short period during the day – such a requirement should be met from within the IT resources already available within the school.) • That it is clear that the existing equipment in the school is insufficient to meet the child's needs without unduly depriving other children of access to the equipment.

Appendix H: Spiral of steps for Action Research



Appendix I: Autism Treatment Evaluation Checklist (ATEC)

ARI/Form
ATEC-1/11-99

Autism Treatment Evaluation Checklist (ATEC)

Bernard Rimland, Ph.D. and Stephen M. Edelson, Ph.D.
Autism Research Institute
4182 Adams Avenue, San Diego, CA 92116
fax: (619) 563-6840; www.autism.com/ari

Project/Purpose:				
Scores: I	II	III	IV	Total

This form is intended to measure the effects of treatment. Free scoring of this form is available on the Internet at: www.autism.com/atec

Name of Child _____ _____ ☐ Male Age _____
Last First ☐ Female Date of Birth _____
Form completed by: _____ Relationship: _____ Today's Date _____

Please circle the letters to indicate how true each phrase is:

I. Speech/Language/Communication: *[N] Not true [S] Somewhat true [V] Very true*

N S V 1. Knows own name
N S V 2. Responds to 'No' or 'Stop'
N S V 3. Can follow some commands
N S V 4. Can use one word at a time (No!, Eat, Water, etc.)
N S V 5. Can use 2 words at a time (Don't want, Go home)
N S V 6. Can use 3 words at a time (Want more milk)
N S V 7. Knows 10 or more words
N S V 8. Can use sentences with 4 or more words
N S V 9. Explains what he/she wants
N S V 10. Asks meaningful questions
N S V 11. Speech tends to be meaningful/ relevant
N S V 12. Often uses several successive sentences
N S V 13. Carries on fairly good conversation
N S V 14. Has normal ability to communicate for his/her age

II. Sociability: *[N] Not descriptive [S] Somewhat descriptive [V] Very descriptive*

N S V 1. Seems to be in a shell – you cannot reach him/her
N S V 2. Ignores other people
N S V 3. Pays little or no attention when addressed
N S V 4. Uncooperative and resistant
N S V 5. No eye contact
N S V 6. Prefers to be left alone
N S V 7. Shows no affection
N S V 8. Fails to greet parents
N S V 9. Avoids contact with others
N S V 10. Does not imitate
N S V 11. Dislikes being held/cuddled
N S V 12. Does not share or show
N S V 13. Does not wave 'bye bye'
N S V 14. Disagreeable/not compliant
N S V 15. Temper tantrums
N S V 16. Lacks friends/companions
N S V 17. Rarely smiles
N S V 18. Insensitive to other's feelings
N S V 19. Indifferent to being liked
N S V 20. Indifferent if parent(s) leave

III. Sensory/Cognitive Awareness: *[N] Not descriptive [S] Somewhat descriptive [V] Very descriptive*

N S V, 1. Responds to own name
N S V 2. Responds to praise
N S V 3. Looks at people and animals
N S V 4. Looks at pictures (and T.V.)
N S V 5. Does drawing, coloring, art
N S V 6. Plays with toys appropriately
N S V 7. Appropriate facial expression
N S V 8. Understands stories on T.V.
N S V 9. Understands explanations
N S V 10. Aware of environment
N S V 11. Aware of danger
N S V 12. Shows imagination
N S V 13. Initiates activities
N S V 14. Dresses self
N S V 15. Curious, interested
N S V 16. Venturesome - explores
N S V 17. "Tuned in" — Not spacey
N S V 18. Looks where others are looking

IV. Health/Physical/Behavior: *Use this code: [N] Not a Problem [MI] Minor Problem [MO] Moderate Problem [S] Serious Problem*

N MI MO S 1. Bed-wetting
N MI MO S 2. Wets pants/diapers
N MI MO S 3. Soils pants/diapers
N MI MO S 4. Diarrhea
N MI MO S 5. Constipation
N MI MO S 6. Sleep problems
N MI MO S 7. Eats too much/too little
N MI MO S 8. Extremely limited diet
N MI MO S 9. Hyperactive
N MI MO S 10. Lethargic
N MI MO S 11. Hits or injures self
N MI MO S 12. Hits or injures others
N MI MO S 13. Destructive
N MI MO S 14. Sound-sensitive
N MI MO S 15. Anxious/fearful
N MI MO S 16. Unhappy/crying
N MI MO S 17. Seizures
N MI MO S 18. Obsessive speech
N MI MO S 19. Rigid routines
N MI MO S 20. Shouts or screams
N MI MO S 21. Demands sameness
N MI MO S 22. Often agitated
N MI MO S 23. Not sensitive to pain
N MI MO S 24. "Hooked" or fixated on certain objects/topics
N MI MO S 25. Repetitive movements (stimming, rocking, etc.)

Appendix J: Usability Testing with parents over the Summer period

Usability Testing: Parent and Teacher Feedback - Version 4 (categories, voice output, colour coding, labelling of images and displaying the sentence strip fullscreen)

1. The colours of the background and sentence strip are:
    a. Visually over-stimulating- I would prefer a lower contrast.
    b. Easy on the eye and is engaging.
    c. Distracting me from looking at the items displayed on the page.
    d. Of low contrast and allows me to concentrate on my sentence structure.

    Comments: -
    _____
    _____
    _____
    _____

2. The voice output in the App is:
    a. Distracting.
    b. Reinforcing for me and encourages me to attempt verbalisation of words.
    c. Cool because its familiar (local accent- voice compared to synthesised voice).

    Comments: -
    _____
    _____
    _____
    _____

3. The size of the symbols within the App are:
    a. Right for me.
    b. Very small.
    c. Just a little too small to see them properly.
    d. A little too big.
    e. Other (please specify):
    _____

4. The layout of the categories are clear and simple.
    a. Yes b. No

5. The pictures used within the categories are appropriate and clear.

a. True b. False

6. It was difficult to find a picture I wanted which was located in the categories.

   a. Yes b. No

7. The App is effective in providing me with the ability to find a picture of my choice and add it to the sentence strip.

   a. True b. False

8. The function of the X button on the sentence strip was:

   a. Difficult to figure out.
   b. Effective in its purpose.
   c. Difficult to use.
   d. Easy to use.
   e. I would prefer another option to delete the picture

      Please identify a more suitable option:
      _____

9. I was able to delete a picture from the sentence strip within two attempts of clicking the X button.

   a. Yes b. No

10. The expand button in the sentence strip was:

    a. User-friendly and easy to use.
    b. Difficult to understand its purpose.
    c. Effective in discriminating sentence structure from communication.
    d. I would prefer another option to view the sentence strip.

       Please identify a more suitable option:
       _____

Additional comments about the App:
_____
_____
_____

Appendix K: An Example of a Questionnaire used in the final stages of Data Collection with Stakeholders

Name of child-_____

Communication-

1. Did your child use PECS symbols in the home prior to using the App?

Yes No

2. Did your child use PECS symbols in the community prior to using the App?

Yes No

3. Did your child, at any time, use the App to communicate needs or wants while in the home?

Yes No

4. Did your child use the App to communicate needs or wants while out in the community with you or others?

Yes No

5. Did your child show preference to using the iPad and App as opposed to using their PECS folder?

Yes No

6. Did your child show willingness to engage with the App?

Yes No

7. Did your child's sentence structure increase (e.g. begin using "I want" symbol when they previously would not have done this or using two symbols when they previously used one)?

Yes No

8. Did your child learn to vocalise new words as a result of engaging with the App?

Yes No

9. Did your child attempt vocalisation of words as a result of engaging with the App?

Yes No

Independence-

10. Did your child use the camera feature to take their own images?

Yes No

11. Did your child show interest in using the camera feature?

Yes No

12. Did your child show ability to potentially learn how to independently use the camera feature?

Yes No

13. Did your child engage with images within the App that you assisted them to take?

Yes No

14. Did your child take control of their iPad (i.e. carry it with them independently)?

Yes No

15. Did your child learn to request when the device needed to be charged?

Yes No

16. Can your child charge their device independently?

Yes No

Social Inclusion-

17. Has your child initiated engagement with you while he/she was using the iPad and App?

Yes No

18. Has your child initiated engagement with siblings while he/she was using the iPad and App?

Yes No

19. Did your child ever engage with extended family, friends or members of the public while he/she was using the iPad and App?

Yes No

Attention Span-

20. Do you feel that your child is engaging in tasks for a longer period of time?

Yes No

21. Do you feel that your child engages for greater periods of time when communicating with you or others?

Yes No

22. Do you feel that your child's attention span has increased as a result of using the iPad and App?

Yes No

Behaviour that challenges-

23. Does your child engage in behaviours that challenge?

Yes No

24. If yes, do you think that the occurrence of incidents has decreased?

Yes No

25. Has the duration of behaviour that challenges decreased?

Yes No

26. Has your child learned to express what is causing them upset (verbally or through the App) or request a coping mechanism (e.g. a chew toy) to assist them with calming techniques when engaging in behaviours that challenge?

Yes No

27. Do you feel that the use of this PECS App was an effective intervention for your child?

Yes No

28. Please give further details where you feel appropriate:

_____
_____
_____

Appendix L: Semi-Structured Interview Schedule

Interview questions for parents of potential participants in Nano Nagel School:

1. **How often do your child currently use PECS?** *E.g. daily, specific activities, only when requesting something they don't have the verbal vocabulary for?*
2. **Does your child only use PECS when in school or do they use it for everyday living?** E.g. home, in the community
3. **In your opinion, is your child motivated to communicate using PECS?**
4. **In your experience have you identified any negative aspects to PECS?**
5. **What, if any, aspect would you like to change in the current PECS system?**
6. **Do you feel that developing your childs PECS vocabulary is time consuming and costly?**

---

7. **Do the children currently use the iPad at home?**
8. **If so, do they request permission to access the iPad or is it freely available to them?**
9. **Would you foresee any difficulty using a smaller device e.g. iPad mini vs ipad2 due to fine motor skills with the children?**
10. **How often do they use the iPad?**
11. **What purpose/s do they use it for?** E.g. academic or social?

---

12. **Which Apps in particular do the children use on the iPad?**
13. **Do any of the children currently use a specific communication App/s?** *If so, what App/s?*
14. **If they already use a communication app what are the benefits and downfalls of using these Apps?** [skip if no communication App used]
15. **Are any of the children currently using or have the ability to use the camera function to take their own pictures using an iPad?**
16. **What features would you like to see incorporated into the proposed App for the children?**
    a. *Voice output- automatic or personalised (explain the concepts)?*
    b. *Picture library- generic or individual (explain the concepts)?*
    c. *Colour scheme of the app*
    d. *others*
17. **Are there any other aspects that you feel should be considered in the development of this App?**

Interview Questions for staff of Nano Nagel School:

1. **How often do the children currently use PECS? E.g. daily, specific activities, only when requesting something they don't have the verbal vocabulary for?**
2. **Are you aware if the children only use PECS when in school or do they use it for everyday living? E.g. home, in the community**
3. **In your experience have you identified any negative aspects to PECS?**
4. **What, if any, aspect would you like to change in the current PECS system?**

---

5. **Do the children currently use the iPad in school?**
6. **Would you foresee any difficulty using a smaller device e.g. iPad mini vs ipad2 due to fine motor skills with the children?**
7. **How often do they use the iPad?**
8. **What purpose/s do they use it for? E.g. academic or social?**

---

9. **Which Apps in particular do the children use on the iPad?**
10. **Do any of the children currently use a specific communication App/s? If so, what App/s?**
11. **If they already use a communication app what are the benefits and downfalls of using these Apps? [skip if no communication App used]**
12. **Are any of the children currently using or have the ability to use the camera function to take their own pictures using an iPad?**
13. **What features would you like to see incorporated into the proposed App for the children?**
    a. **Voice output- automatic or personalised (explain the concepts)?**
    b. **Picture library- generic or individual (explain the concepts)?**
    c. **Colour scheme of the app**
    d. **others**
14. **Are there any other aspects that you feel should be considered in the development of this App?**

Appendix M: Focus Group Plan

Plan for Onei Focus group May 5th 2015- Nano Nagle School

Opening:

- Thank parents and staff for coming.
- Reassure participants that any information gathered will remain confidential and no single person will be identified.

User Scenarios (10-15 minutes):

- Reading and discussing the accuracy of the scenarios and what changes could be made.

Prototype App (30 minutes):

- Highlight that the aim is to gain more user requirements and features.
- Begin by showing the paper prototype.
- Distribute checklists to each person and ask people to form groups of 2-3 persons.
- Then use the App to show swiping and voice output.
- Allow 10 minutes for people to complete the checklist and ask questions.
- Collect individual checklists and thank participants for coming.

Appendix N: User Scenario

User Scenario

1. School:

Sarah is six years old and is currently using her P.E.C.S. folder on a daily basis; however, some of her pictures are going missing. Sarah's friend loves to shred pictures as she also has a diagnosis of ASD and engages in sensory stimulating activities. When Sarah is looking for a picture and cannot find it she begins to cry, hit her own head and throws her P.E.C.S. book across the room. These behaviours continue until the teacher can figure out what Sarah was trying to communicate. This situation occurs several times a week for Sarah.

With the introduction of a Communication App and mobile device, Sarah has control over her own vocabulary. The risk of this situation occurring would reduce dramatically. As a result of using the App Sarah's engagement in behaviours that challenge has greatly reduced as she has instant access to all of the vocabulary she requires. Sarah's friend shows interest in the mobile device and engages with Sarah using this but she does not attempt to delete any of the pictures.

2. Home:

Ben is eight years old and has now started to use P.E.C.S. with his brother to tell him what game/toy he wants to play with next. Ben and his brother always play with Thomas the Tank Engine trains but today, Ben is sitting in front of his folder, rocking and putting his fingers in his ears. Ben's brother shows Ben the picture of the trains and prompts him to engage in picture exchange but Ben continues the stemming behaviours. Ben continues this behaviour for 30 minutes while his brother takes out every toy in the play room and offers it to Ben. Ben's brother then takes out a Barney teddy that Ben has not shown interest in for years. Ben engages with his brother. Ben's mom later realised that she had removed the picture some months previous as Ben did not use the picture any longer and she was making space for more recent pictures.

With the introduction of a Communication App and mobile device, Ben could have easily communicated his needs. If he did not have the picture of Barney in his vocabulary library he would have been able to take a picture of the toy using the camera function and present it to his brother. The use of an App would have given Ben greater independence over his vocabulary and it would have reduced the frustration on both himself and his brother. Ben would not have needed to engage in stemming behaviours for 30 minutes if he had instant access his own vocabulary.

3. Community:

Ella loves going grocery shopping with her mom and they go to the local supermarket every Thursday after school to do the week's shopping. They do not take Ella's P.E.C.S. folder with them as it is heavy and bulky and Ella refuses to use it when she is out in the community. Ella and her mom entered the supermarket, with Ella pushing the trolley. However, when they were half way down the first aisle, Ella threw herself on the floor and began screaming, kicking and banging her head off of the floor. Ella's mom was unaware of the reason for this behaviour and she became increasingly embarrassed. Ella's mom picked Ella up (still engaging in these behaviours) and left the supermarket. Ella remained upset until they got home. The next day, while Ella was at school, her mom went to do the shopping. Ella's mom

then realised that after going half way down the first aisle, the cakes were not in their usual place. The shop had been rearranged for marketing purposes.

If Ella used a Communication App with a mobile device she would have had instant access to the vocabulary she needed to explain to her mom why she was so upset. Ella would have been able to request 'cake' using the App. Ella's mom would then have been able to explain the changes within the shop to Ella and this would have reduced her anxiety and frustration. Ella's use of a mobile device within the community would be perceived as being 'normal' as opposed to using the P.E.C.S. folder.

4. School:

Jack is seven years old and is continuing to progress in learning the stages of P.E.C.S. during his school day. His teachers work very hard with him in making progress; however, Jack has not commenced any verbalisation of words as of yet. The classroom that Jack is placed in is a busy classroom and has limited staff resources. When Jack engages in picture exchange, his teacher uses social and tangible reinforcers; however, she has omitted her verbalisation of vocabulary when engaging with Jack. She does not do this intentionally but sometimes she gets distracted by another child and just forgets.

Through the use of a Communication App and mobile device Jack would have greater consistency to encourage verbalisation. The Communication App is predictable for Jack and provides him with a voice output that reinforces his communication on each picture exchange.

Appendix O: Usability Testing Stakeholder Feedback Sheet

Onei Focus Group May 5th Nano Nagle School Listowel

Your role (parent, teacher, speech and language therapist): _____

What would you like to see added or changed in the App?
What features do you like?

Feature (e.g. colour scheme, pictures, behaviours of the App, voice, camera)	**Comments**

Appendix P: Ethical Approval form Institute of Technology Tralee

INSTITUTE OF TECHNOLOGY TRALEE
RESEARCH ETHICS COMMITTEE APPLICATION FORM

It is essential that this form is completed fully and the relevant enclosures are received if the study is to receive proper scrutiny by the Research Ethics Committee (REC). Please refer to the checklist below before sending the form.
Please also ensure that all supporting documents are attached securely to the12 copies of the application form and secured together with a staple.
Applications which are not collated in sets will be returned to the author.
Address to send application: REC Application, Development Office, Institute of Technology Tralee, Co. Kerry, Ireland.

Checklist
Please indicate if the following have been enclosed by selecting Yes/No/Not applicable options below. Please forward copies of the form and relevant enclosures required as outlined below.

	Yes	**No**	**Not applicable**
12 copies of application form (double-sided if possible)	☐	☐	☐
12 copies of protocol (no more than 4 A4 : pages double-sided if possible**)**	☐	☐	
12 participant consent form(s)	☐	☐	☐
12 participant information sheet(s)	☐	☐	
12 Questionnaire (s)	☐	☐	☐
12 copies of lead applicant's CV on 1 side A4	☐	☐	☐

I confirm that if necessary, a member of the research team can attend the next REC meeting to address application. The representative of the research team must be the Principal Investigator or other person thoroughly familiar with and able to represent all aspects of the protocol.	☐	☐	

SECTION 1 Details of applicant(s)

1. Short title of project *(in not more than 6 words)Using Mobile Devices to Aid Children with Autism*

Full title:

Period for which approval is sought:

2. Applicant *(All correspondence will be sent to this address unless indicated otherwise.)*
Family Name Forename: Title:

Present appointment of applicant:

Qualifications:
Address (for correspondence regarding application):
Tel: Fax: Email:

3. Other workers and departments/institutions involved

Name	Department	Appointment

4. Signature of relevant personnel

Applicant

I undertake to carry out the work outlined here in accordance with the principles of the Declaration of Helsinki (5th Revision 2000) - and its amendments. The details contained in this document are, to the best of my knowledge, correct. I confirm that any training necessary for the execution of this project will be undertaken by current and by future researchers on the project.

Signature of applicant Date

Head of Department/Supervisor with overall responsibility for the project

I am fully aware of the details of this project and agreeable for it to continue as outlined here. I can confirm that the necessary facilities and resources are available to the researcher.

Signature Date NAME AND TITLE IN CAPITALS DEPARTMENT: ……..

SECTION 2 Details of project

This section must be completed. A copy of the protocol should be enclosed with the application form but it is not sufficient to complete questions by referring to the protocol. Please summarise in the space provided.

5. Aims and objectives of project (i.e., what is the intention of the project?)
Study endpoints: *Summary of practical benefits/improvements which are envisaged*
6. Background to study
7. Brief outline of project (i.e., what do you intend to do?)
8. Study design
9. i) Hypothesis or key research questions to be answered
ii) Plan of Investigation?
iii) Procedures or investigations involving risks to participants' well being or safety (What, when, how often and risk(s) associated with all procedures)?

10. Does the study fall into any of the following categories? Pilot ☐ Yes ☐ No N/A Multi-centre study ☐ Yes No ☐ N/A Undergraduate student project ☐ Yes No ☐ N/A If student project, what course is being undertaken, in which institution? ***If this is a multi-centre study, please complete the details below, otherwise go to Question 11.***
i) Which centres are involved?
ii) Which ethics committees have been approached, and what is the outcome to date?

iii. Who will have overall responsibility for the study?

iv. Who has control of the data generated?

11. Location of the study?

12. Has any funding been obtained, or is it being sought by the investigator in respect of this study (include research grants)?

- funding applied for Yes o No
- funding secured Yes o No o

i. If relevant, where will research funds be lodged? N/A

i. Does the investigator(s) have any direct personal involvement (e.g. financial, share-holding etc) in the sponsoring organisation? Yes o No

If yes, give details:

i. Will any restrictions be placed on dissemination of findings or publication of results? Yes o No

If yes, give details:

13. Schedule

Proposed starting date: Proposed duration:

SECTION 3 Recruitment of participants

14. a) How will the participants in the study be selected, approached and recruited?

b) What inclusion and exclusion criteria will be used?

15. How many participants will be recruited and of what age groups?

16. How will the control group (if used) be selected, approached and recruited; what inclusion and exclusion criteria will be used? (Type *NA* if no controls and go to question 18).

17. How many controls will be recruited and of what age groups?

18. Are the participants included in this study involved in any other research investigation at the present time?

☐ Yes No ☐ Not known

If *Yes*, please give details.

19. Will participants receive any payment or other incentive to participate?

☐ Yes No

i. If yes, give details of incentive per participant?

ii) If yes, what is the source of the incentive?

SECTION 4 Consent

20. Is *written* consent to be obtained?

Yes ☐ No

If Y*es*, please attach a copy of the consent form to be used.
See appendices

If no, please justify

21. Does the study include participants for whom English is not a first language?

☐ Yes No ☐ NA

If *Yes* give details of arrangement made; if *No* please justify.

22. Are the participants in one of the following groups?

Children under 16 Yes ☐

No ☐Unknown

People with learning difficulties Yes

☐ No ☐Unknown

Other vulnerable groups e.g. psychological disorders, dementia ☐

Yes ☐ No x ☐Unknown

If <u>Yes</u>, please complete the details below, otherwise go to Question 23.

i) What special arrangements have been made to deal with the issues of consent and assent, e.g. is parental or guardian agreement to be obtained, and if so in what form?

ii) In what way, if any, can the proposed study be expected to benefit the individual who participates?

23. Will the participant be given a written information sheet or letter?

Yes ☐ No

If *Yes*, please attach copy to this application form.
If *No*, please justify.

SECTION 6 Risks and ethical problems

24. Are there any ethical problems or considerations that the investigators consider to be important or difficult with the proposed study?

X Yes ☐ No

If *Yes*, please give details:

25. Are there any potential hazards to participants or patients?

☐ Yes x No

If *Yes*, please give details, and give the likelihood and details of precautions taken to minimise them, and arrangements to deal with adverse events, including reporting to the relevant authorities.

26. Is this study likely to cause discomfort or distress to participants/patients?

☐ Yes x No

If *Yes,* estimate the degree and likelihood of discomfort or distress entailed and the precautions to be taken to minimise them.

SECTION 7 Indemnity and confidentiality

Product liability and consumer protection legislation make the supplier and producer (manufacturer) or any person changing the nature of a substance, e.g. by dilution, strictly liable for any harm resulting from a consumer's use of a product.

27. i) What arrangements have been made to provide indemnification and/or compensation in the event of a claim by, or on behalf of, a participant for negligent harm?

☐ N/A

ii) What arrangements been made to provide indemnification and/or compensation in the event of a claim by, or on behalf of, a participant for non-negligent harm?

☐ N/A

iii) Will an undergraduate student be involved directly in conducting the project?

☐ Yes ☐ No

28. i) Will the study data be held on computer?

Yes ☐ No

ii) If Yes, will the data be held so that participants cannot be identified from computer files (i.e. no name, address or other potential identifier such as GMS or RSI number) ?

Yes ☐ No

iii) If No, give reasons

iv) Will records (preferably paper records) linking study participant ID numbers with identifying features be stored confidentially? ☐ Yes ☐ No

29. Will the study include the use of any of the following?

Audio/video tape recording Yes ☐ No

Observation of participants Yes ☐ No

If *Yes* to either,

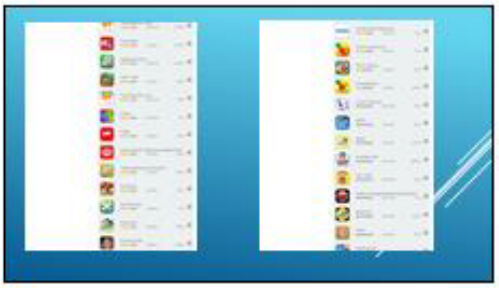
a) How are confidentiality and anonymity to be ensured?

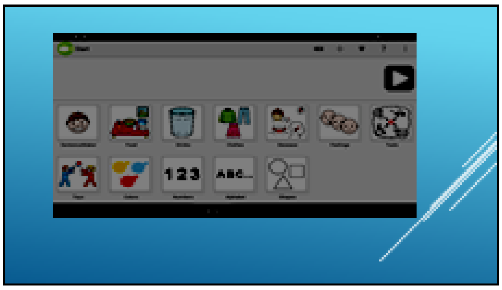
b) What arrangements have been made to obtain consent?

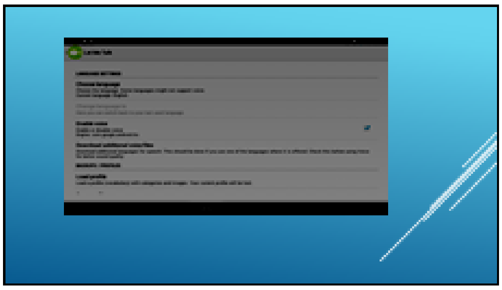
c} What will happen to the tapes at the end of the study? [(Note: they should usually be stored for data verification or transcribed)] All data stored for five years and then destroyed.

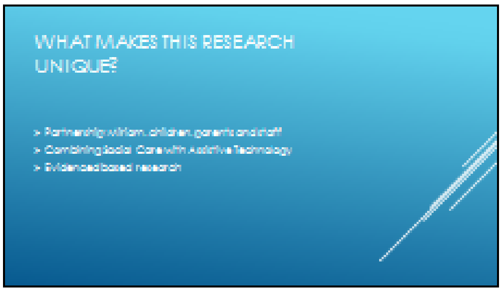
Please ensure that you complete the checklist on the front cover of the application form and include all relevant enclosures.

Appendix Q: Information Meeting Powerpoint

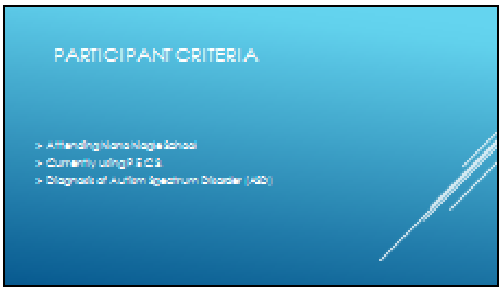


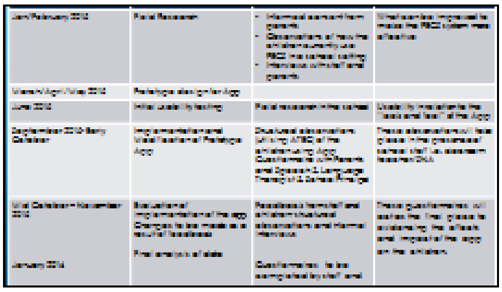





WHAT MAKES THIS RESEARCH UNIQUE?
Combining Social Care with Assistive Technology
Evidenced based research


BENEFITS OF THESE APPS


PARTICIPANT CRITERIA
Attending Nano Nagle School
Currently using P.E.C.S
Diagnosis of Autism Spectrum Disorder (ASD)




DATA COLLECTION
Profile of each child in order to establish a baseline
Conduct ATEC
Interviews with staff and parents
Questionnaires with staff and parents


CRITERIA OF ASSESSMENT
Autism Treatment Evaluation Checklist (ATEC)
Social and Academic


WHAT HAPPENS AFTER DECEMBER 2015?
An information session will be offered to participants parents and staff presenting the findings from the research
Data will be analysed and presented in a Thesis along with publication of some results in academic journals
Results presented at conferences


QUESTIONS AND COMMENTS?
KEEP CALM AND ASK ME QUESTIONS


Thank You

Appendix R: Letters of Information

U302- Graduate Research Office,
Institute of Technology Tralee,
North Campus,
Dromtacker,
Tralee,
Co. Kerry.

Nano Nagle School,
Listowel,
Co. Kerry.

Dear Staff,

My name is Miriam O' Sullivan and I am a Masters by Research Social Care student at the Institute of Technology Tralee. As part of my Masters by Research I am carrying out a research study in which I would like for a group of children with Autism Spectrum Disorder in attendance of your school to participate in.

The title of the research is 'an exploration of the effects of the use of communication apps through mobile devices on children with Autism Spectrum Disorder'. The aim of the research is to identify the effects that these apps have on the children i.e. their communication, independence, learning, behaviour, social interaction and social inclusion. I would like to receive your permission in conducting the research on one group of children with ASD in your school.

In order for the children to participate they are required to meet two criteria; a diagnosis of ASD and are currently using PECS. The research would involve the children using smartphones/Tablet/iPad and an app to communicate. The apps are based on the same system as PECS so no extra training is required for them.

The research will be undertaken from October 2014 to October 2016. Please find attached a timetable of proposed engagements with you and your school. The month of September will consist of establishing baselines for each child through the use of the Autism Treatment Evaluation Checklist which I will conduct. I will hold an information session for the principal and staff to introduce the research. The date of the information session will be given to you by your Principal. The children will begin using the devices in September 2015 and I will visit your school monthly to conduct the Autism Treatment Evaluation Checklists. In January 2016, I will be requesting you to complete a brief questionnaires based on your evaluations of the use of these apps and smartphones/tablets.

I would greatly appreciate your permission and co-operation to carry out this research. This is a relatively new concept that has proven successful in countries such as Australia and the United States of America. If you have any further questions please contact on [redacted] or [redacted] I look forward to hearing from you.

Yours Sincerely,
Miriam O' Sullivan,
Graduate Research Assistant,
Institute of Technology Tralee.

Appendix S: Letters of Informed Consent

U302- Graduate Research Office,
Institute of Technology Tralee,
North Campus,
Dromtacker,
Tralee,
Co. Kerry.

Dear Parent(s)/ Guardian(s),

As you are aware, your child has been suggested by your school's speech and language therapist as a suitable participant for the research as already outlined.

Please find enclosed a letter of informed consent for your child. This letter of informed consent is essential in order for your child to participate in the research titled "An Exploration of the effectiveness of the use of Communication Apps through mobile devices on children with Autism Spectrum Disorder". This research will commence in February 2015 and will end in March 2016 (please see timeline attached).

The aim of the research is to identify the effects that these Apps have on the children i.e. their communication, independence, learning, behaviour, social interaction and social inclusion. The current research has shown that the use of these Apps have had positive effects on the children. There has not as yet been any negative effects identified as a result of using these Apps and devices. The research will take place within your child's school. The research will not involve home visits and you will not incur any expenses if your child participates in this research.

The research involves your child using a smartphone/tablet and an App that is designed to help them communicate. The Apps are based on the same system as PECS so no extra training is required for your child.

Your child will be provided with the use of a mobile device for the duration of the data collection phase (September – December 2015). Your child will be using this device along with a Communication App that we are currently developing. This App is based on PECS and will therefore be replacing your child's PECS folder for the duration of the research.

Prior to the implementation of the App I would like to meet parents and staff to conduct interviews. In these interviews I would like to gather general information as to what your child may need incorporated into the App.

I would again like to inform you that participation in this research is voluntary and you and your child can withdraw from the research at any time and without any consequences.

If you have any questions please do not hesitate to contact me. I can be contacted on [redacted] or [redacted]

I would greatly appreciate your participation in this research. If you would like your child to participate this research please complete and return the informed consent letter (attached) to your school Principal on or before 03/02/2015.

Kind regards,
Miriam O' Sullivan

Informed consent

I _____ consent to my child, _____ , participating in the research titled 'an exploration of the effectiveness of the use of communication apps through mobile devices on children with Autism Spectrum Disorder' which is being conducted by Miriam O' Sullivan (Institute of Technology Tralee).

I have been provided with the relevant information (aim of research, steps involved in the research and any risks) to facilitate my ability to provide informed consent for my child's participation.

I understand that my child will be provided with the use of a mobile device for the data collection phase of the research.

I understand the information provided and I understand that I can withdraw my child at any time without any consequences.

Signature: _____ Date:_____

Print name: _____

Informed Consent for participants

I would like to help Miriam with her project.

.

I would like her to show me how to use my P.E.C.S. on my iPad

I can stop and finish the project if I want to.

Signed (using a handprint, writing or drawing done by the participant):

_____

Appendix T: Usability Analysis of existing Apps (Example Template)

Name of App: _____

Feature:	Yes	No	Not Applicable	Positive Feature of the overall App	Negative Feature of the overall App
Concept:				➢	➢
➢ The App uses the concept of P.E.C.S. i.e. symbol exchange, reinforcement.					
➢ Can the App be customised to a specific P.E.C.S. phase					
➢ The App uses a "Text-to-Speech" concept					
Text:					
➢ Text style/font is easy to read					

➢ Text style/font can be changed by the user					
➢ Text size can be changed by the user					
➢ The language used is simple and clear					
<u>Ease of Use:</u>					
➢ Can the symbol sizes be increased or decreased by the user (if it is a P.E.C.S. concept based App)					
➢ Navigation (tools that are required to use the App i.e. erase button, home button) is easy to see and use throughout the use of the App					

➢ Can Voice control be turned on/off					
➢ Is there a camera option within the App to customise pictures					
➢ Is the App specified for people with ASD					
➢ Is the App supported by several operating systems (i.e. android, IOS or windows)					
➢ Is the sentence strip displayed full screen					
➢ Does the App require further payment to access full features					

Appendix U: UPA Designing for the User Experience framework

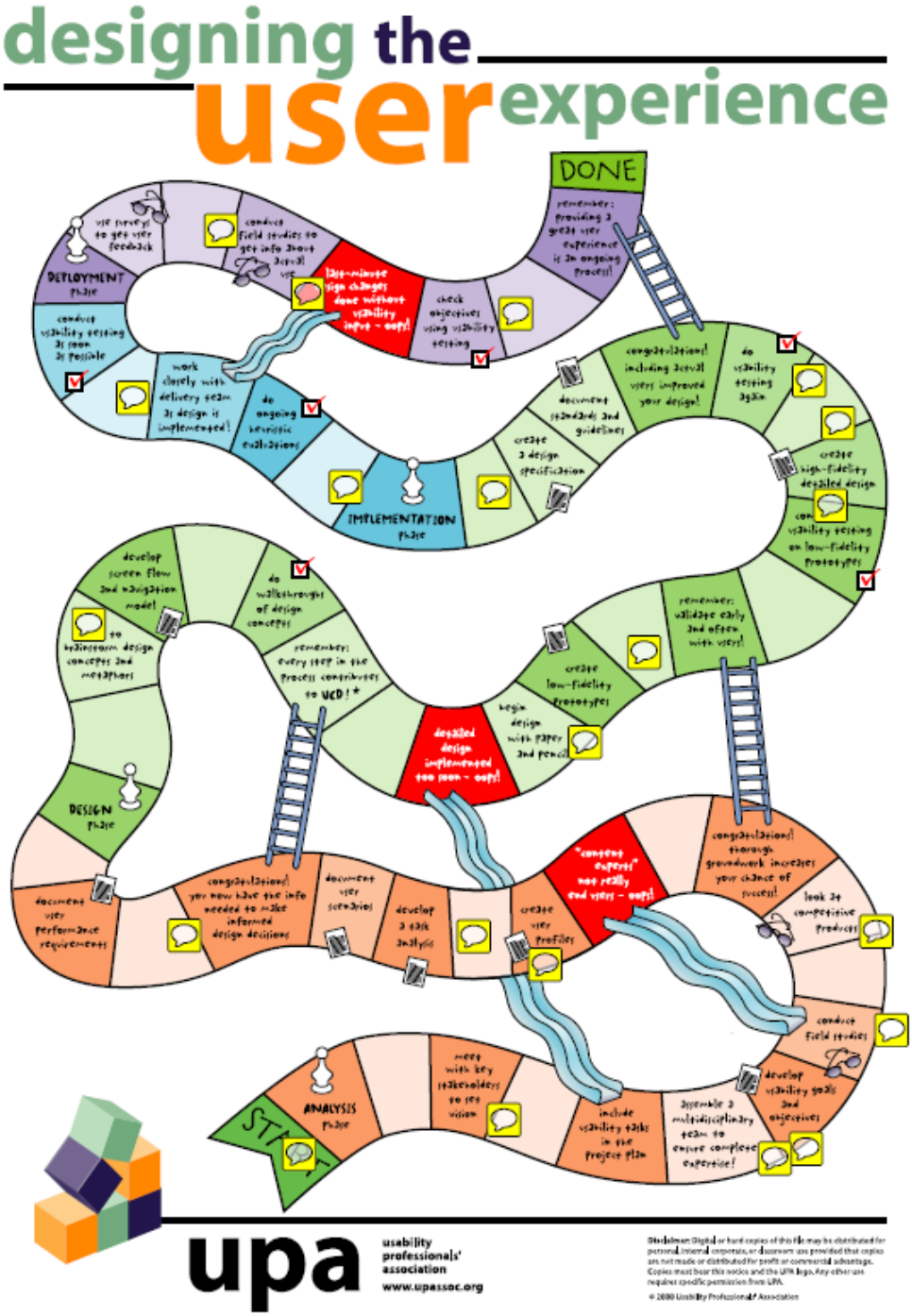
Appendix V: Usability Goals for the research

Goal	**What it measures**	**Example benchmarks – These should be measured while doing the tasks mentioned above**
Effective	How well the task is done. *Completed and accurate.* *Are any mistakes being made?*	➢ Users will be able to locate the desired picture, add it to the sentence strip (by tapping it) and present it to the communicative partner. ➢ Users can display the sentence strip full screen (by swiping up) directly before presenting it to the communicative partner. ➢ Users can delete error symbols/pictures within two attempts of tapping the x button.
Efficient	The speed (with accuracy) that the user completes the task's. *Time* *Look for screen layout or navigation issues that may be making the task more difficult than it needs to be.*	➢ The user can access their desired vocabulary in three clicks or less (one click to access the App, one click to access the category and one click to select the desired picture/symbol). This should be completed within 4 seconds. ➢ The user can navigate to the desired category in under 5 seconds. ➢ The user can build a sentence of their choice (with respect to their level of P.E.C.S.) and present it to the communicative partner in under 10 seconds. ➢ The user can clear the sentence strip in

		under 3 seconds after the communicative partner returns the device to the user. ➢ The user can undo an error in 5 seconds.
Engaging	How pleasant or satisfying the visual design of the App is. *Look for signs of confusion.*	➢ Users focus on the vocabulary (i.e. selecting images to put on the sentence strip) as opposed to the background colour of the interface (this will be measured by observing the users interaction with the interface and what position on the screen they are tapping). ➢ Are users attracted to the interface? (this will be measured by asking the users- some are verbal and some may use pictures to respond) ➢ Do they engage with the App? (this will be measured by observing whether they choose to use the App and select pictures to create a sentence or if they walk away from the App when presented with it- the App will be presented on a daily basis to familiarise the users with its presence)
Error Tolerant	Preventing errors caused by user interaction. *Cannot create a scenario of possible mistakes as users may become frustrated which could result in displaying behaviours that challenge. ABA principle- error-less*	➢ Any errors that occur will be recorded through observations of use and the App will be modified and redesigned to resolve any issues. ➢ The buttons are distinctive and the

	learning!	function of each button is clear. ➢ The language used is simple and appropriate/familiar to the user.
Easy to Learn	Scope for users to build their knowledge without deliberate effort. How much training did the children require? Will they need more training in later stages of the App when there are more features, etc.?	➢ The user is independently using the App e.g. camera function to develop their vocabulary. ➢ The researcher will demonstrate the use of the App to the classroom teacher. The researcher will provide a script of instructions for the session and possible demands for the teacher to use with the children. ➢ Each child will be given a demonstration of the App by the classroom teacher (so as to eliminate any anxieties in relation to interactions with an unfamiliar person i.e. the researcher. Positive reinforcement will be used for the initial stages (i.e. if a child requests and item in the App they will receive it immediately).

Appendix W: Adapted UPA Designing for the User Experience framework



Comments from Analysis phase to Deployment phase:

1. Ethical Approval:
   Distribute letters of information and informed consent through the research site (the school distributes the letters to potential participants and their parents on behalf of the researcher in order to comply with ethical guidelines).
2. Information sessions:
   1 with classroom teachers and Speech and Language Therapists,
   1 with parents of participants.
3. Stakeholders (children with ASD, parents, classroom teachers and Speech and Language Therapists) and the research team.
4. Conduct interviews with stakeholders
5. Observations of current systems/metaphors in place (i.e. P.E.C.S. system)
6. Analysis of existing Apps using checklist tool developed by Miriam.
7. To be completed by classroom teachers. Confidentiality is essential and only the primary researcher has access to these profiles. These profiles assist the researcher in observations and in developing user requirements. Data Protection Act.
8. Conduct participant observations every fortnight. The purpose of this is to be familiar with a child's typical behaviours prior to formal observations in the implementation phase.
9. Development of a framework for recording usability goals.
10. Using participant profiles, interview data and observation data to inform this. Metaphor was decided on prior to engagement with users- P.E.C.S.
11. Liaise with stakeholders.
12. Show this to classroom teachers and speech and language therapists.
13. Researcher to up skill in order to learn programming languages to develop the App (HTML5, CSS3 and JavaScript). Collaborate with Programmers (iMAR).
14. Conduct focus group to expose parents, teachers and Speech and Language Therapists to the first version of the prototype.
15. Introduce some of the participants to version 2 of the prototype.
16. Liaise with parents and children twice during summer months (once in July and once in August) to ensure that the researcher is meeting the needs of the children.
17. Mandatory meetings with parents and staff to discuss implementation. Provide parents and staff with an information pack that includes: a social story for transition, a best practice guideline image, a 'how-to' guide for the App and a contract of purpose. Allow parents and staff time to engage with the App and provide them with training for use.
18. Provide parents and staff with a written plan of implementation. Researcher is on-site for the first week to demonstrate use and ensure children are being trained correctly on how to use the App. Researcher visiting each classroom and child to assist with implementation.
19. Use P.E.C.S. to receive feedback from children- symbol for the App and a happy/sad face or thumbs up/down.
20. Autism Treatment Evaluation Checklist (ATEC), Observations and Usability Testing.
21. Conduct questionnaires with parents and staff in relation to usability and effectiveness (October and December 2015).

Appendix X: Written plan of Implementation

Plan of Implementation of Onei for Parents of participants:

Part 1

1. Introduce the iPad with the child when they are engaging in one-to-one tasks.
2. Explain to the child that this is their iPad and P.E.C.S. folder.
3. Begin by demonstrating how to open the App.
4. Then explain the interface to the child (i.e. each category and you tap the picture of the category to find the picture you want. If a child is unable to use the categories, all vocabulary loads onto the home screen when the App is first opened. However, please try and encourage the use of categories.
5. Demonstrate how to construct a sentence (tap the 'I want' symbol and then tap a symbol of your choice).
6. Narrate your actions at all times.
7. When you have constructed your sentence, demonstrate how to display the App in full screen mode (tap the expand button↙↗).
8. When the App is in full screen mode, tap each symbol individually to activate the audio.
9. Once completed, tap the cancel button (✖) to return to the full set of vocabulary.
10. Give the device to the user and prompt the user to create a sentence.
11. When they have completed their sentence, request them to tap the expand button.
12. Once the App is in full screen mode, ask the user to give you the iPad (use a gestural prompt if necessary- i.e. hold an open hand out towards the user).
13. When the user has given you the iPad, request that they tap each symbol.
14. When the user complies with this, prompt them (verbally) to tap the cancel button.

*** N.B. Please ensure that you use high levels of verbal praise when teaching the child how to use the App.**

Part 2

15. When the child has tried the above process a few times, demonstrate to them how to use the camera feature.
16. Begin by again modelling how you engage with the camera feature.
17. Tap the camera symbol (📷) to access the device's camera.
18. Take your desired picture. *Remember you are narrating your steps each time.
19. Click on 'use photo' at the bottom of the screen.
20. A text box and save button will then appear in the home screen.
21. Enter the desired label for the image.
22. Click save.
23. Your image will be saved to the 'my pictures' category.
24. Tap this symbol to demonstrate to the user how to access their images.
25. Add the image to the sentence strip by tapping on it.
26. Display in full screen (↙↗).
27. Tap image (no audio is available for individual images; however, tapping the image is P.E.C.S. protocol).
28. Tap cancel button (✖) to return to home screen.
29. Repeat steps 17-28 with the user.

***N.B. Please allow the user to explore the App; give them control over their vocabulary!**

Appendix Y: Social Story

My new communication App

Miriam is giving me (child's name)

an iPad,

an Otterbox cover and

a ChatBag to help me communicate.

Miriam will show me (child's name) how to use my new iPad and App.

Miriam will visit me (child's name) every two weeks to see if I (child's name) need help with my App.

My App is the same as my P.E.C.S. Book.

=

I can choose to use my folder or the App when talking to my family and friends.

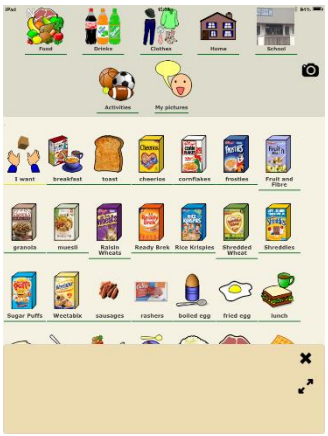
I can take my own pictures with my iPad.

I can use my iPad in school, at home and when I am out and about!

When Christmas comes I (Child's name) will be finished working with Miriam.

Appendix Z: How-to-guide

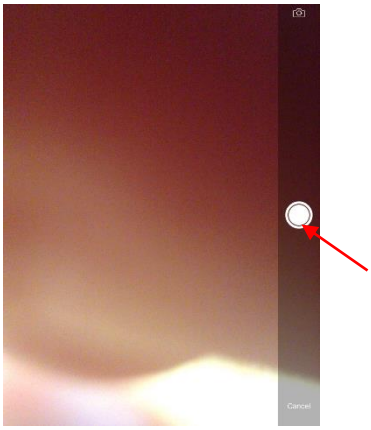
1. Click on the App icon to open.
2. All images are automatically displayed.



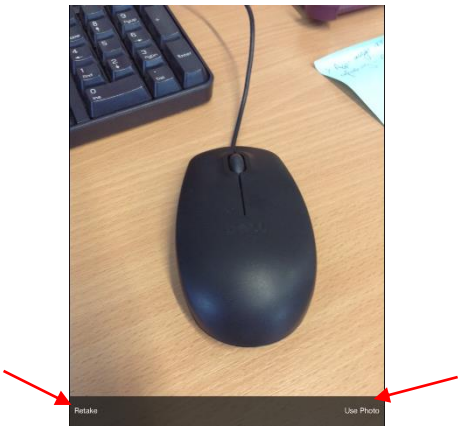
3. Click on the images at the top to filter images into categories.

4. To take your own image, click on the camera symbol.

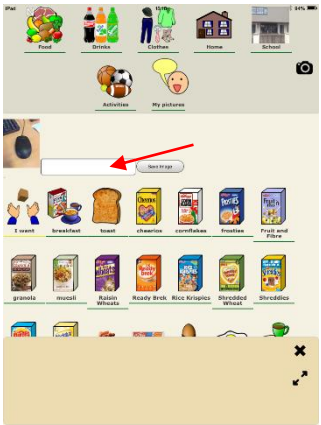
5. Focus the camera on the item you would like to capture and press the middle button.



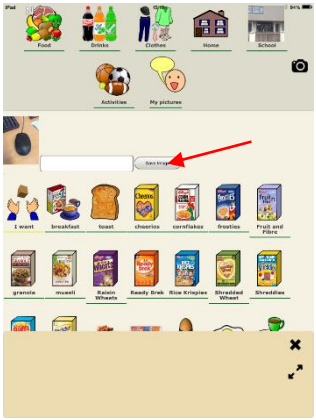
6. Choose either ‘use photo’ or ‘retake’.



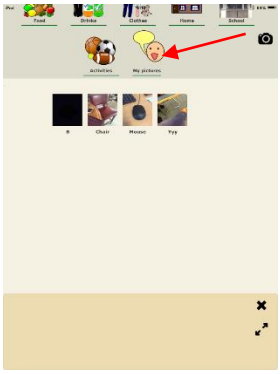
7. If you choose ‘use photo, you will be returned to the home screen where you are required to label the image.



8. Click save.

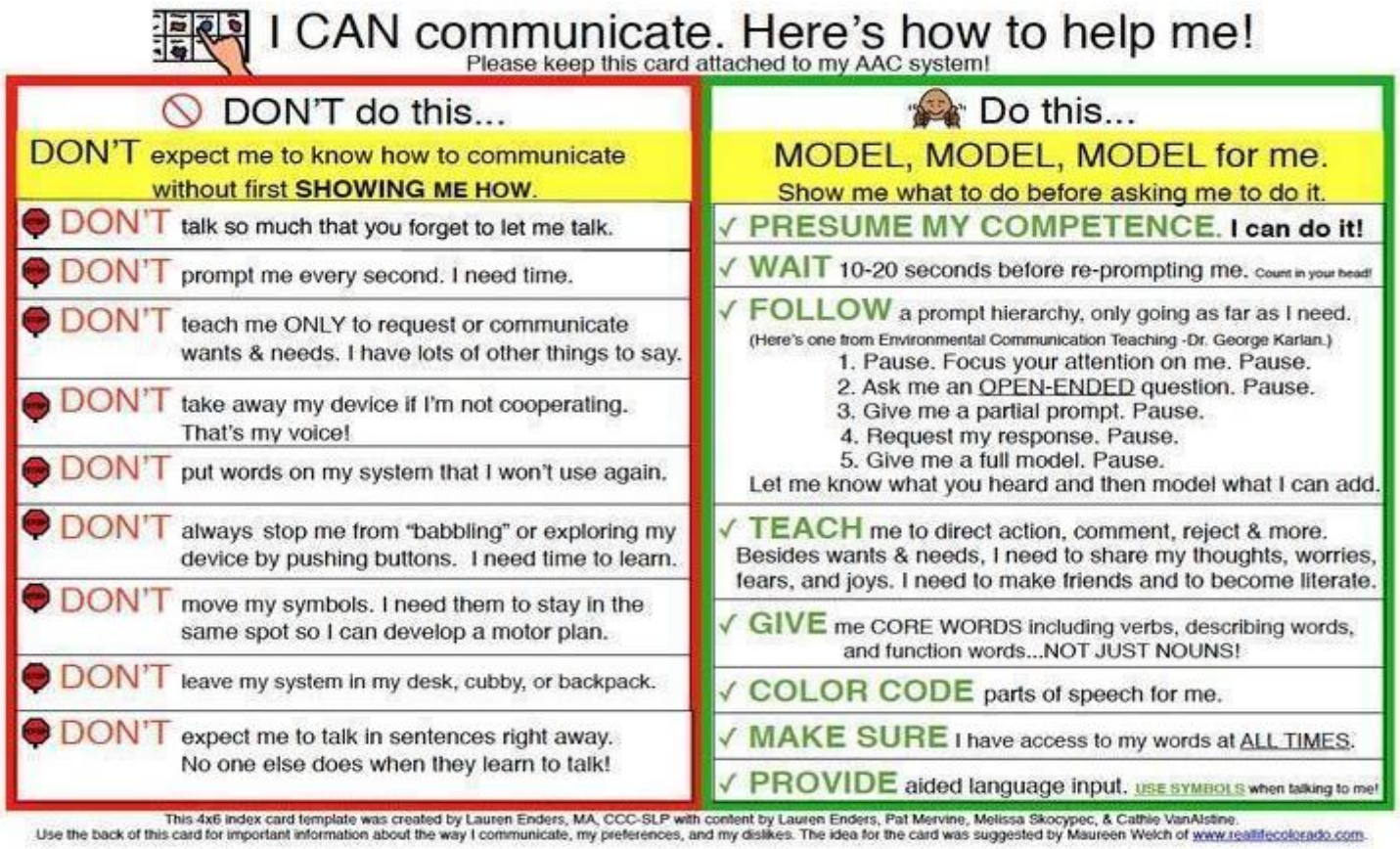


9. The image is saved to ‘my pictures’ category.
10. Tap ‘my pictures’ to see your personalised symbols.



11. To create a sentence, tap the images you desire.
12. They will appear on the sentence strip.
13. Tap the expand button (⤢) to put the sentence strip into fullscreen mode.
14. Tap the cancel button (✖) to reset the sentence strip

Appendix AA: Visual Support for Best Practice Guidelines



Appendix BB: Formal Observation Checklist

✓ =Yes; X= No; S= Sometimes

	[child's name]	Comments
Communication:		
Labelled items verbally		
Attempted vocalisation of words		
Consistently communicated using P.E.C.S.		
Independently communicated using P.E.C.S.		
Responded to staff engagement/communication using P.E.C.S.		
Initiated communication with staff (without P.E.C.S.)		
Initiated communication with peers (without P.E.C.S.)		
Initiated communication with staff (with P.E.C.S.)		
Initiated communication with peers (with P.E.C.S.)		
Made eye contact when communicating with P.E.C.S.		
Carried device with them		
Used the chatbag for portability		
Communicated by shouting/screaming		
Behaviour:		
Engaged in behaviours that challenge		
Used P.E.C.S. to explain their frustration		
Engaged in self-harming behaviours		
Engaged in behaviours that challenge towards peers (verbal or physical)		
Engaged in behaviours that challenge towards staff (verbal or physical)		
Consistently engaged in academic tasks as per instruction from staff (attention span)		
Operational competencies		

- Can turn device on/off		
- Can take device in/out of sleep mode		
- Can open Onei		
- Can change the volume as required		
- Can charge device independently		
- Will request for device to be charged when needed		

Appendix CC: Mid-Term Evaluation Questionnaire

U302 Post Graduate Research Office,
North Campus,
Institute of Technology Tralee.

Dear Parents(s),

I would like to begin by thanking you for taking the time to engage with this research and for all of the work you are doing with your child to facilitate the use of this App. As mid-term break is approaching I would be grateful if you would complete the attached questionnaire. This questionnaire will allow me to review the App and address any major concerns that may be causing your child frustration. I will do my upmost to meet the needs of your child; however, please keep in mind that this is a prototype App and any suggestions that cannot be immediately resolved will be included in the recommendations chapter of my dissertation. You and your child's identity will remain anonymous.

When you are completing the questionnaire please provide as much constructive criticism as possible as this is a learning curve for everyone involved. Your contribution to this research is invaluable. You know your child better than anyone; thus, your feedback is most important for this research.

Please return your completed questionnaire to the school **on or before Wednesday 21st October** 2015. If you have any questions please do not hesitate to contact me on [redacted]

Kind regards,
Miriam O' Sullivan,
Post-Graduate Researcher,
Institute of Technology Tralee.

Parent Feedback Questionnaire- October 2015

Please **circle** your response

Child's name: _____

1. Can your child locate a symbol of their choice, add it to the sentence strip and present it to a communicative partner?
   Yes No
2. Can your child display the sentence strip full screen by tapping the expand button?
   Yes No
3. Can your child use the "X" button to delete a symbol?
   Yes No
4. Can your child navigate the use of the categories?
   Yes No
5. Are there errors occurring within the App that are causing difficulty or frustration for your child?
   Yes No
   (a) If yes, please give details:

_____
_____
_____

6. Is the vocabulary that is available meeting the needs of your child?
   Yes No
   If no, please give details:
   _____
   _____
7. Can your child use the camera function within the App?
   Yes No
8. Are there any other issues with the App that you would like considered?
   Yes No

If yes, please give details:

_____
_____
_____

Appendix DD: End of Intervention Evaluation Questionnaire

Dear Parent(s),

We are now at the end of the data collection phase and I would like to sincerely thank you for all of your help and co-operation over the past 12 months. The final observations are taking place this week and we are then complete. However, I have one last questionnaire for you to complete.

Attached is a questionnaire for each child that participated in the research. It has 5 sections and will take approximately 5-7 minutes to complete. The purpose of this questionnaire is to triangulate the data already collected and to ensure validity and reliability. Therefore, this questionnaire is crucial to the completion of the research. I would be grateful if you would complete this and return it to Kerry on or before Wednesday 09/12/2015.

If you have any questions please do not hesitate to contact me via [redacted]. I look forward to our celebration on the 22nd December in the assembly hall at 10.00.

Kind regards,
Miriam O' Sullivan,
Institute of Technology Tralee.

Parent feedback questionnaire:

Name of child-_____

Communication-

1. Did your child use PECS symbols in the home prior to using the App?

   Yes No
2. Did your child use PECS symbols in the community prior to using the App?

   Yes No
3. Did your child, at any time, use the App to communicate needs or wants while in the home?

   Yes No
4. Did your child use the App to communicate needs or wants while out in the community with you or others?

   Yes No
5. Did your child show preference to using the iPad and App as opposed to using their PECS folder?

   Yes No
6. Did your child show willingness to engage with the App?

   Yes No
7. Did your child's sentence structure increase (e.g. begin using "I want" symbol when they previously would not have done this or using two symbols when they previously used one)?

   Yes No
8. Did your child learn to vocalise new words as a result of engaging with the App?

   Yes No

9. Did your child attempt vocalisation of words as a result of engaging with the App?

Yes No

Independence-

10. Did your child use the camera feature to take their own images?

Yes No

11. Did your child show interest in using the camera feature?

Yes No

12. Did your child show ability to potentially learn how to independently use the camera feature?

Yes No

13. Did your child engage with images within the App that you assisted them to take?

Yes No

14. Did your child take control of their iPad (i.e. carry it with them independently)?

Yes No

15. Did your child learn to request when the device needed to be charged?

Yes No

16. Can your child charge their device independently?

Yes No

Social Inclusion-

17. Has your child initiated engagement with you while he/she was using the iPad and App?

Yes No

18. Has your child initiated engagement with siblings while he/she was using the iPad and App?

Yes No

19. Did your child ever engage with extended family, friends or members of the public while he/she was using the iPad and App?

Yes No

Attention Span-

20. Do you feel that your child is engaging in tasks for a longer period of time?

Yes No

21. Do you feel that your child engages for greater periods of time when communicating with you or others?

Yes No

22. Do you feel that your child's attention span has increased as a result of using the iPad and App?

Yes No

Behaviour that challenges-

23. Does your child engage in behaviours that challenge?

Yes No

24. If yes, do you think that the occurrence of incidents has decreased?

Yes No

25. Has the duration of behaviour that challenges decreased?

Yes No

26. Has your child learned to express what is causing them upset (verbally or through the App) or request a coping mechanism (e.g. a chew toy) to assist them with calming techniques when engaging in behaviours that challenge?

Yes No

27. Do you feel that the use of this PECS App was an effective intervention for your child?

Yes No

28. Please give further details where you feel appropriate:

Appendix EE: Review of Research Articles to develop Best Practice Guidelines for developing with Children with Autism Spectrum Disorders (ASD)

Year	Author(s)	Title
2015	Dinsmore	Future of Assistive Technology Workshop Summary
2015	Chien et al.	iCan: A tablet-based pedagogical system for improving communication skills of children with autism
2015	Wakeel et al.	A Usability Evaluation of Arabic Mobile Applications Designed for Children with Special Needs-Autism
2015	Pagani Britto	T*owards Web Accessibility Guidelines for People with Autism Spectrum Disorder*
2014	Bernardini et al.	ECHOES: An intelligent serious game for fostering social communication in children with autism
2013	Benton and Johnson	Designing Technology with a vulnerable population: Children with special needs and the role of the adult
2013	Frauenberger et al.	Conversing through and about technologies: Design critique as an opportunity to engage children with autism and broaden research(er) perspectives
2011	Weiss et al.	Usability of Technology Supported Social Competence Training for Children on the Autism Spectrum
2011	Porayska-Pomsta et al.	Developing Technology for Autism: An interdisciplinary approach

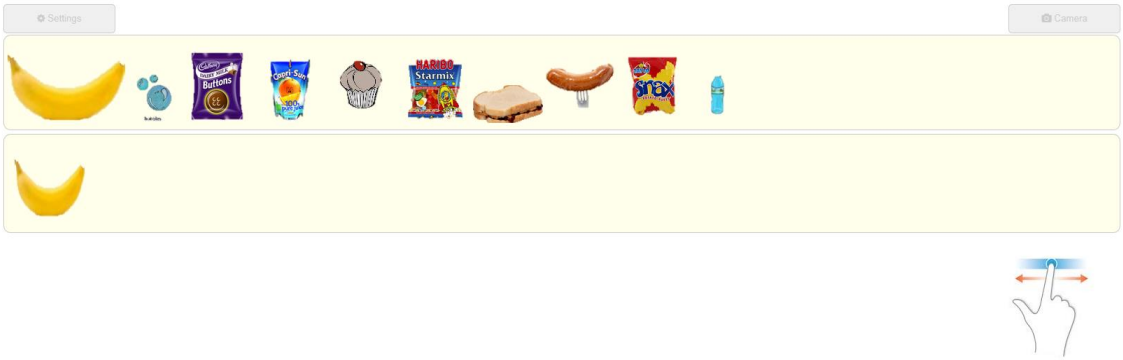
2010	Abott et al.	Learning difference and digital technologies: a literature review of research involving children and young people using assistive technologies 2007-2010
2009	Walsh and Barry	A Classroom Investigation of Software Design Requirements for Special Needs Learners
2008	Putnam and Chong	Software and Technologies Designed for People with Autism: What do users want?

Appendix FF: From hello world to Onei

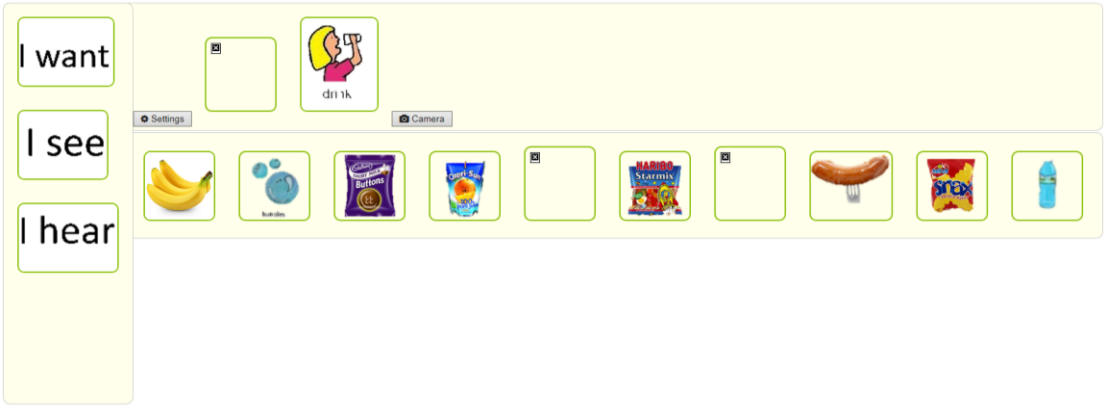
Evolution of Onei Prototypes:
11/04/2015

22/04/2015

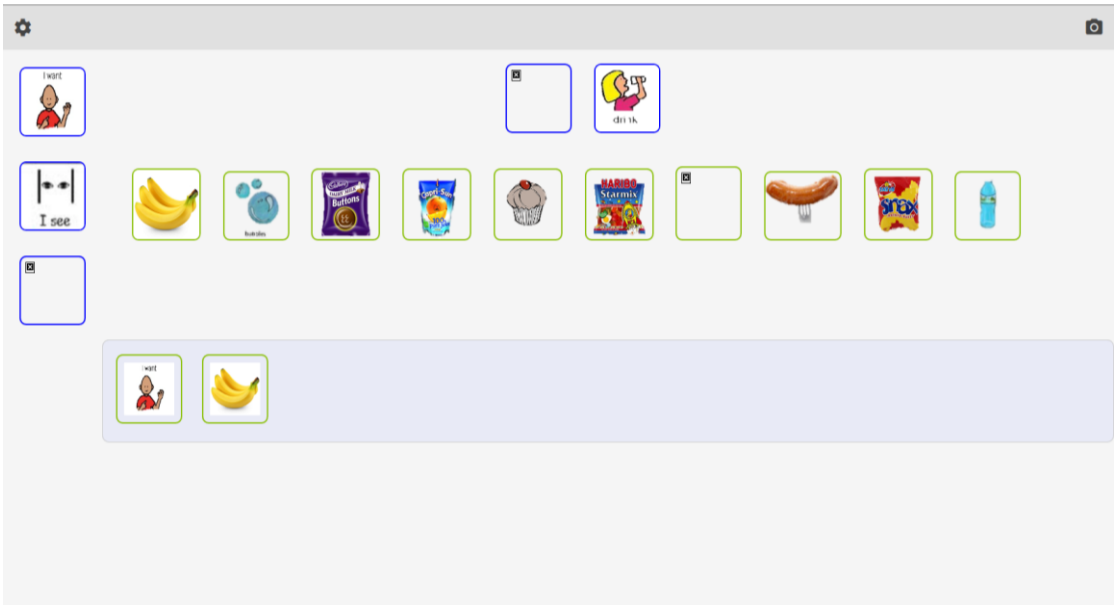
30/04/2015



Focus Group 12/05/2015- version 1

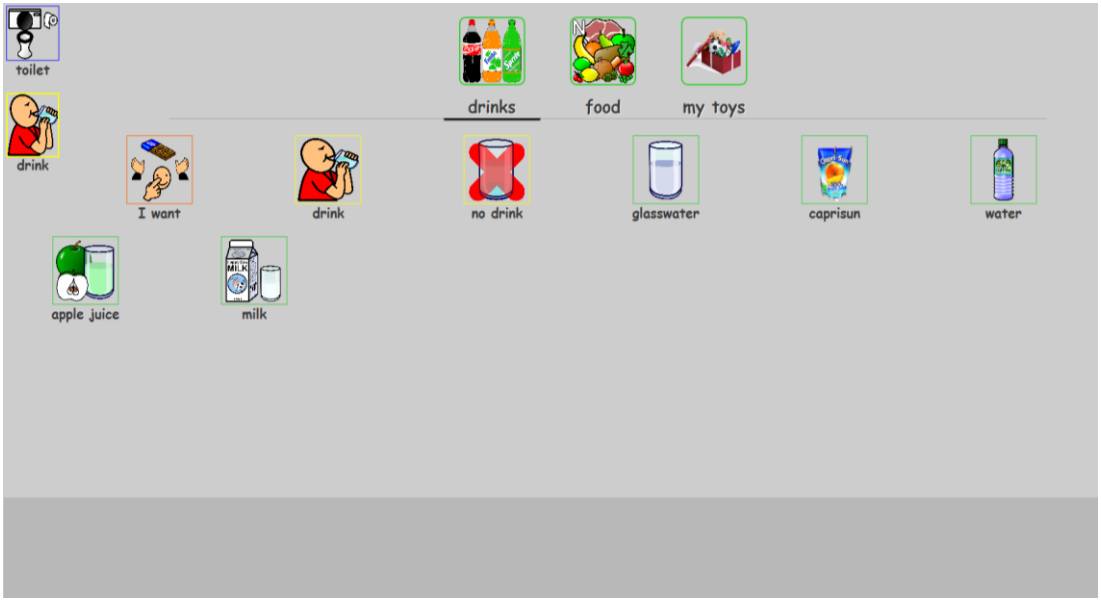


Version 2 08/06/2015

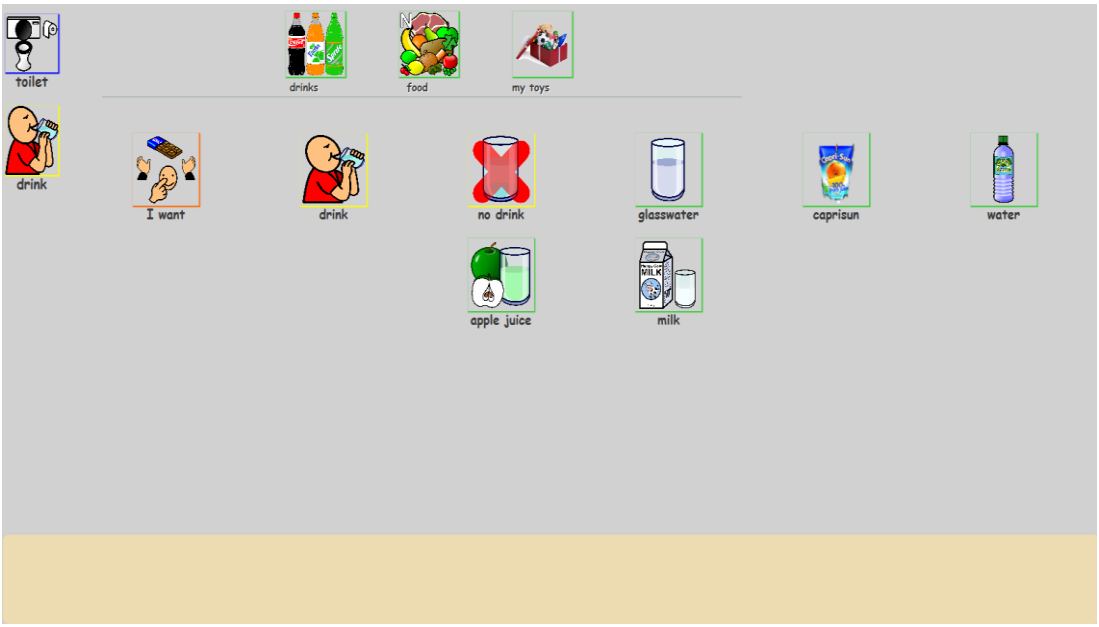


15/06/2015 Categories

Usability testing 2: 22/06/2015

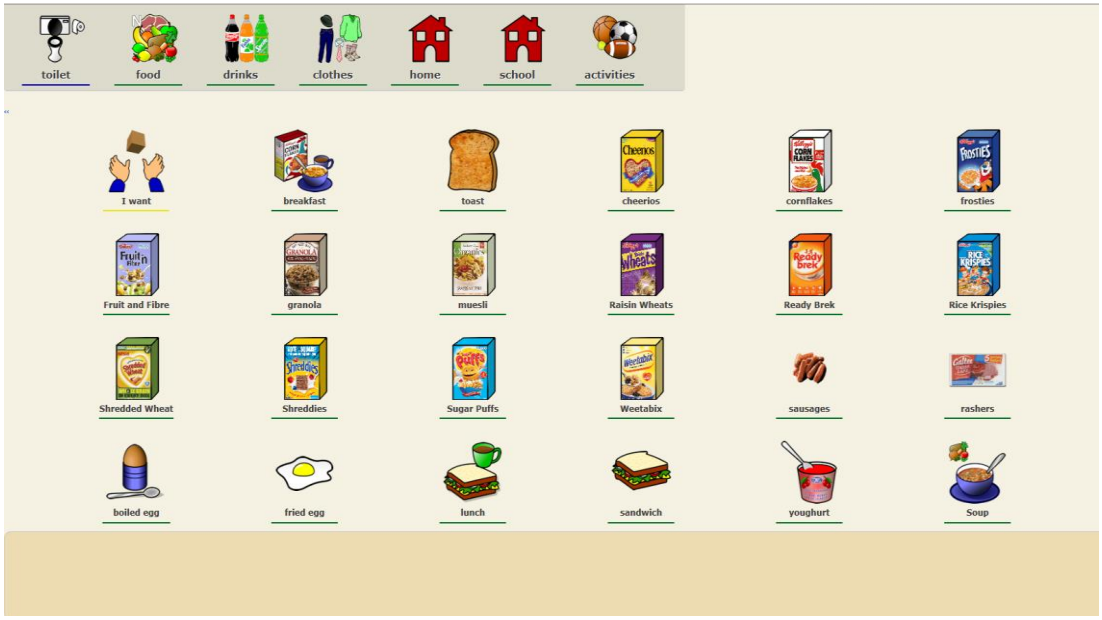


Usability testing 3: 29/06/2015

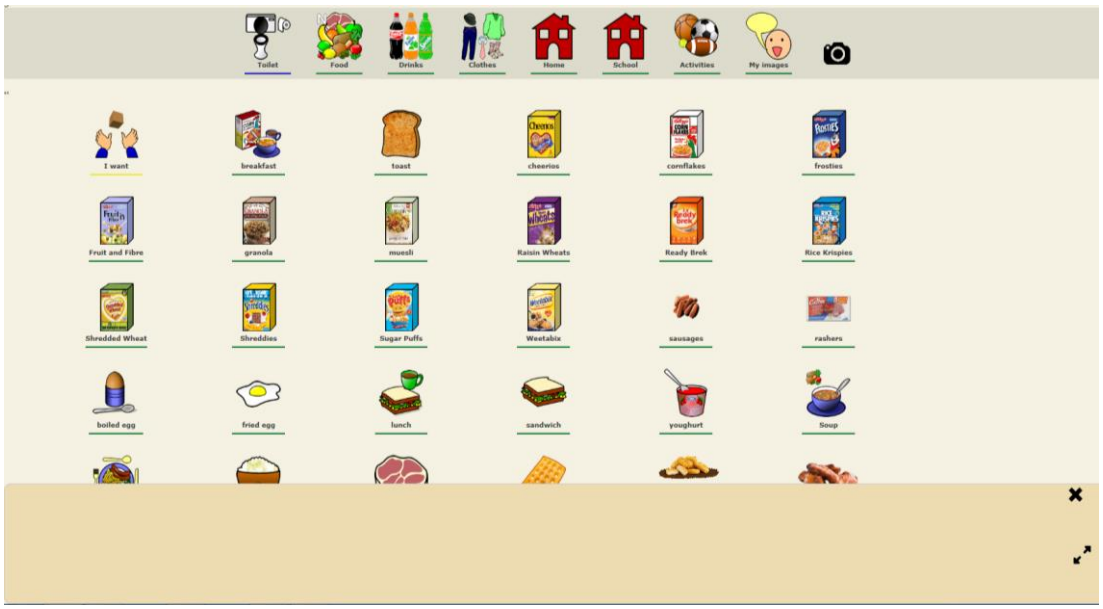


Usability testing session 3:

Version 4 18/08/2015:



Version 5: 26/08/2015



Final Version 11/09/2015

Appendix GG: Staff step by step Usability Testing Instructions

Dear [teacher],

I have made some progress with the development of the App as a result of the feedback gained from the focus group that you participated in. I am wondering if you would mind conducting a usability testing session with me to introduce the App to John Nicholas, Daniel and Keelan? The session would take no more than 10 minutes and circle time would be a perfect opportunity to gain feedback from the children. I have attached below information in relation to the session; the first page outlines details of the session. Page 2 & 3 provide you with some guidelines and a script of instructions and the final pages are the checklist that I would be completing on the day. The aim of this session would be to gain feedback from the children and determine how they interact with the updated version of the App and what they would like changed or modified. I will be present to assist you with the session and also to observe the behaviours of the children.

I would greatly appreciate your assistance in this matter. I am proposing to conduct this session **Tuesday 9th June.** Please confirm with Kerry if you would like to participate in this and if this day suits you and your class.

If you have any questions or would like to discuss any aspect of the material attached please contact me via email: [redacted] or phone: [redacted]

Kind Regards,
Miriam.

Usability Testing: 1st session (Onei version 2)

Location: Nano Nagle School
Duration: 10 minutes (during circle time activity)
Participants: 3 boys (who are all verbal), classroom teacher, special needs assistant X2.
Training: The classroom teacher will lead the session with the children. The researcher will give the teacher a 5 minute training session on the use of the App, along with guidelines on running the session (see guidelines attached).
Tasks to be carried out:

1. The children will be instructed to construct a sentence of their choice. All items within the App will be made available to the children on successful completion of the sentence.
2. The children will be asked to delete a picture/symbol from the sentence strip.
3. The children will be asked to present the sentence strip to their communicative partner and complete the P.E.C.S. protocol by tapping each symbol to activate the voice output (1/2 second reinforcement).
4. The children will be asked about their opinion on the App i.e. colour scheme, swipe feature and voice output.

What will be observed or measured during the test:

1. Effectiveness of constructing a sentence using the App.
2. Effectiveness in deleting a picture/symbol from the sentence strip.
3. Efficiency in constructing a sentence of their choice in under 10 seconds.

4. Efficiency in clearing the sentence strip in under 3 seconds after the communicative partner returns the device to the user.
5. Efficiency in deleting a picture/symbol in under 5 seconds.
6. What position of the screen the user is tapping- focus on the vocabulary or on the background colour.
7. Are the users attracted to the interface? (Ask users if they like the colours and layout of the screen).
8. Do users engage with the App? (Do they choose the App as opposed to their folder or do they walk away from the App without any engagement?).

Appendix HH: Usability Testing Session Script (Staff)

Guidelines for the classroom teacher:

You will be given a demonstration by the researcher (Miriam) on how to use the App. You will lead the session (so as to remove any anxieties the researcher may cause the children).

1. The session will begin by explaining to the children about the App (showing them their P.E.C.S. folder to provide visual support to understand the concept). The following steps are a script to introduce the App:
    a. Today we are going to have a go at using this App. This is the same as using your P.E.C.S. folder to ask for things that you want.
    b. "_____ (Name of researcher/SNA) and I will show you how to use it".
2. Model the use of the App with the researcher or SNA. You will remain the communicative partner. *Please remember to provide the ½ second reinforcement once modelled correctly by researcher/SNA.* The following are the steps that need to be completed: Please talk aloud while completing each of these steps (narrating to explain to the children what you are doing)
    a. Give the device to the researcher/SNA.
    b. The researcher/SNA selects a picture of their choice and presents it to you.
    c. The researcher/SNA taps the symbol/picture on the sentence strip to activate the voice output.
    d. You present the researcher/SNA with the item they requested.
    e. You return the device to the researcher/SNA.
    f. The researcher/SNA selects a picture in error. The researcher/SNA swipes right to remove the symbol/picture.
    g. The researcher/SNA constructs their desired sentence successfully (using P.E.C.S. protocol) and receives tangible reinforcement.
3. You then offer each child a turn to construct their sentence in the same approach as when it was being modelled. Begin by explaining to the children that "we will all take turns using the iPad" and follow these steps:
    a. Give the device to the child. Ask the child "what do you want?"
    b. The child selects a picture of their choice and presents it to you. *If the child does not initiate giving you the device use the open/empty hand approach to prompt.*
    c. The child taps the symbol/picture on the sentence strip to activate the voice output.
    d. You present the child with the item they requested.
    e. You return the device to the child.
    f. Instruct he child to select a picture. Then instruct the child- "can you show me how to take the picture off of the sentence strip". The child needs to swipe right to remove the symbol/picture.
    g. The child constructs their desired sentence successfully (using P.E.C.S. protocol) and receives tangible reinforcement.
4. Once each child has had a turn using the App ask them:
    a. Did they like using the App?
    b. Do they want to use the App or their P.E.C.S. folder?
    c. Do they like the colours in the App?
    d. Do they like the swipe feature? *Demonstrate the swipe in the App if necessary.*
    e. Do they like when the App talks?

- ***No prompts of any kind are to be given to the children unless the child specifically asks for help.***
- ***Keep verbal reinforcement high throughout the tasks.***

<u>P.E.C.S. Protocol for basic communication (as per Phase I- how to teach communication):</u>

- Rules of Communication:
  - Approach communicative partner
  - Deliver message
- Student initiates communication: pick -up, reach and releases.
- Communicative partner holds an open/empty hand to encourage exchange of communication.
- When child is engaging in phase IV, encourage the child to point to each picture as the communicative partner vocalises the label.
- Allow a 3-5 second time delay in order to encourage speech
  - Do not insist on speech
  - Do not withhold reinforcer if student does not speak
  - Honour the exchange
- Communicative partner delivers reinforcer within ½ second, labels item requested and praises child.

Appendix II: Usability Testing Evaluation Checklist (Researcher)

Checklist for usability testing session 1

Childs name:_____

Usability Task	Yes	No	Comments
Users will be able to **locate** the desired **picture**, **add** it to the **sentence strip** (by tapping it) and **present** it to the communicative partner. *(Effectiveness)*			
Users can **delete error** symbols/pictures within **two attempts** of **swiping right**. *(Effectiveness)*			
The user can **build a sentence** of their choice (with respect to their level of P.E.C.S.) and **present** it to the communicative partner in **under 10 seconds.** *(Efficiency)*			
The user **can clear the sentence strip** in **under 3 seconds** after the communicative partner returns the device to the user. *(Efficiency)*			
The user can **undo** an error in **5 seconds.**			

(Efficiency)			
Users **focus on the vocabulary** (i.e. selecting images to put on the sentence strip) as opposed to the background colour of the interface (this will be measured by **observing** the users **interaction** with the interface and what position on the screen they are tapping). *(Engaging)*			
Are users **attracted** to the interface? (this will be measured by **asking** the users- some are verbal and some may use pictures to respond) *(Engaging)*			
Do they **engage** with the App? (measured by observing whether they choose to use the App and select pictures to create a sentence or if they walk away from the App when presented with it. *(Engaging)*			

Appendix JJ: Parent and Staff letter of Implementation

Dear Parent(s)/Guardian,

As you are aware we have commenced implementation of the App (onei) with your child. In order to assist your child with using the App I have developed an implementation plan (see attached). This implementation plan provides you with clear guidelines on how to teach your child how to use the App. It is recommended to implement the plan at least once a day with your child. Your assistance in this matter is crucial to the success of implementation.

Please remember to charge your child's device every night so as to avoid any distress they may feel if their device were to shut off unexpectedly during school. This App was designed with your child's needs at the core; this is a prototype App so please be aware that it is not perfect. If there are any major issues with the App they will be addressed during the mid-term break. Prior to mid-term I will send you a short questionnaire that will aim to identify any issues that need to be resolved for phase 2 of the data collection. For the duration of the data collection I will be observing your child on a fortnightly basis. Your child's teacher/SNA will be present at all times during observations. Upon completion of the data collection phase (December 2015) I will send you a final questionnaire which will be used to assess the effectiveness of the App for your child. In order to complete the questionnaire you will be required to outline your observations; therefore, throughout this data collection phase I would appreciate if you would informally observe your child's:

- Communication (use of the App, spontaneous, increase in vocabulary),
- Interaction (with staff and peers),
- Independence (attempt/use of the camera feature, use of their individual images),
- Attention span and behaviours that challenge (increase or decrease).

Your observations will be invaluable to the research findings and recommendations.

If you have any questions please do not hesitate to contact me via email: [redacted] or phone: [redacted]. Please remember that as a stakeholder in the research you have a right to withdraw your child from participating at any stage and without consequence. I look forward to working with you and your child this term.

Kind regards,
Miriam O' Sullivan,
Post-graduate Researcher,
Institute of Technology Tralee.

Appendix KK: Stakeholder Contract of Purpose

Contract of purpose (Parent)

I, _____, understand that the iPad provided to my child as part of the research "An Exploration of the Effectiveness of the use of Communication Apps through Mobile Devices on children with Autism Spectrum Disorders (ASD)" is for the sole purpose of communication. The iPad mini that is assigned to my child holds the serial number: F5LPP0K4F193. I agree that I will not use the iPad for any other purpose and I will not install Apps on this iPad for myself or my child. I will ensure that my child has access to their iPad at all times and I will ensure that I send the iPad to school with him/her each day. I understand that this iPad is only to be used for the purpose of communication and using it for any other purpose would jeopardise the outcomes of the research.

Signed: _____

Date:_____

Appendix LL: Interview- Additional Stakeholder Comments

What features would you like to see incorporated into the proposed App for the children? *e. Voice output- automatic or personalised (explain the concepts)?* *f. Picture library- generic or individual (explain the concepts)?* *g. Colour scheme of the app* *h. others*	"I would like to have the verbal. Option to turn it off. Pictures- photographs are very personal and they cannot be generalised outside of it. I think they need both. Sensory processing- yes especially with two of them. One is very sound sensitive. Not aware of colour sensitivity"; "A generic voice is fine. The ability to be able to turn it on/off- [participant] is very sensory and auditory is one of her biggest defensive area's- it's often on her terms she may listen to something very loud at times. Having the option of turning if off on days that she is particularly sensory would be good. Pictures- a mixture of symbols and photos. Often with some of the pecs symbols they don't make sense to me. We have always put the words under the photo so that other people know what words we use. We are now trying to use the pecs symbols because we find that now that she's getting older if it doesn't look like the specific picture she can get quiet frustrated with it because [participant] is a perfectionist. When I took the picture of her breakfast years ago, if I now don't lay her breakfast out like the picture she can get quite upset, not every day but some days. It causes us more problems than it solves. For meals and things we can now start moving across to the pecs symbols. Also for some items pecs doesn't give us a symbol that matches the item she is looking for. That is more for food items and places. The actual picture makes more sense to people with ASD as oppose to a symbol. Colour scheme- as neutral as possible more pastel colours. That the colours fade into the background and the picture is the more prominent item on screen. Some of the apps that we did look at, communication ones, the pictures can get lost in the background or the background picture can distort what the child is looking at. [participant] sees things differently she can see things in patterns."; "Access it easily- not too many steps to get into the App if it is too complicated they won't get it! It would be an easy system to put in a picture that the filing system would be straight forwards and pictures that relate to two categories overlap. Some pictures can be applied to two categories but may only be in one. If you have a picture that over laps

	categories that it would be in both categories. It would take extra memory but it means they can access it easily. Voice output- I would love to hear an Irish voice as oppose to an American accent or and English one. I would love for it to be an Irish made App that sounds like something they hear so if we want them to produce a word it is the pronunciation that we would have as opposed to an American one. Picture library- mixture- the option to use your own when the time comes. No iPad in the PECS category. (a) Colour scheme- anything bright is too distracting- nothing that is too over sensitising. Click- sometimes you need it for some of them so it is good to have an option."; "a) I think it would be beneficial ya. It might be more suitable for some children and for some children that mightn't work. I think it would be a good idea ya. More personalised approach for each of them. (b) I think more individualised like I was saying it would be photographs we would use mostly. We tried the symbols and they aren't very obvious at all so they are more clear, the photographs, I suppose once they are individualised. (c) No not to colour. Sound wouldn't a sensory issue there."
Are there any other aspects that you feel should be considered in the development of this App?	"No, they don't have access to the P.E.C.S. book a such. My class is not an ASD unit it is a mixed class"; "no"; "To be able to build the communication like the "I want". To take the paper based PECS and put it into an App. To have the ability to have a visual schedule in there. To me a visual schedule is part of communication. With [participant], she works very much off a schedule and if she knows what's happening next she happy to continue. With [participant] we use "finish" a lot and it helps with her transitioning so a symbol for finish would help. No and Stop can be quiet negative. Another thing we use quiet a lot is "first" and "then" so having those symbols would help too."; "A bank of pictures within the App prior to use. Stuff specific to Ireland, our holidays, our school bus isn't always yellow and our flag is not on the App".

Appendix MM: Participant Profile

Dear Staff,

We are at the stage of the research where we have now received informed consent from parents. I am hoping to commence observations of the children using their PECS folders in the coming weeks. In order to effectively carry out these observations, I require some information about the children. This information will aim to build a participant profile and will be key for observations and data collection. This data will only be used to help contextualise the participant's behaviours while I am undertaking the observations and help make my observations more accurate and will not be directly reported on in the dissertation. An overview of the participants will be provided in the dissertation but will not be provided on an individual basis to maintain anonymity. The data will be treated with the upmost confidentiality and will be maintained in accordance with full ethical procedures and will be destroyed once the data collection and analysis phase has been completed.

I appreciate that you have very busy schedules, however, I would greatly appreciate if you would complete the attached questionnaire. This is the questionnaire that will develop the participant profiles.

I would greatly appreciate if you would have these questionnaires completed on or before Thursday 16th April 2015. I will collect them from your school when they are completed. If you have any further information (relating to a child's communication, social interaction or behaviour) that you would like to add to the questionnaire in relation to the participant please feel free to do so.

If you have any questions please do not hesitate to contact me. I can be contacted on [redacted] or [redacted] I greatly appreciate your assistance in this research.

Kind regards,
Miriam O' Sullivan,
Graduate Research Assistant,
Institute of Technology Tralee.

Staff Questionnaire for Participant Profile

Childs name: _____

Identification number: (will be completed by the researcher): _____

Communication:

1. Is the participant verbal or non-verbal? (please circle one)

   Verbal Non-Verbal

2. Does the participant engage in peer-to-peer communication? (please circle one)

   Yes No

   2 (a) If yes, do they engage using PECS?

   Yes No

   2 (b) If yes, do they engage verbally?

   Yes No

3. Does the participant consistently use P.E.C.S. to communicate their needs/wants to staff/parents?

   Yes No

4. Approximately, how many words can the participant use at any one time in order to communicate their needs/wants?

   _____
   _

5. What phase of P.E.C.S. is the participant currently on?

   _____
   _

Social Interaction:

6. Does the participant engage with staff/parents?

   Yes No

7. Does the participant engage in peer-to-peer social interactions?

   Yes No

8. Does the participant make eye contact?

   Yes No

9. Does the participant usually pay attention with addressed by someone?

   Yes No

Behaviours:

10. Does the participant engage in self-injurious behaviour e.g. hitting, banging, kicking objects, biting, etc.

    Yes No

11. If yes, please specify which behaviours the participant engages in

    _____
    _____

12. Does the participant hit or injure others?

    Yes No

13. Does the participant insist on adhering to rigid routines?

    Yes No

14. Is the participant sound sensitive?

    Yes No

15. Does the participant engage in destructive behaviours (e.g. attempting/actual damage to property)

    Yes No

16. Is the participant anxious at particular times?

    _____

17. Is the participant visually unhappy/crying on a regular basis?

_____

18. Does the participant have particular triggers that could cause any of the above behaviours?

_____

19. Does the participant have any other behaviours that they engage in?

_____

20. Does the participant display any physical signs prior to engaging in any of these/other behaviours?

_____

Any other information in relation to communication, social interaction and behaviour:

_____
_____

Appendix NN: Final Usability Testing Evaluation with all ten participants

Checklist for usability testing with individual participants

	Participant 1	Participant 2	Participant 3
Locate a picture, add it to the sentence strip and present it to the communicative partner. Effective			
Display the sentence strip full screen by tapping the expand button prior to presenting it to the communicative partner. Effective			
Delete an error symbol within two attempts of tapping the cancel button. Effective			
Access their desired vocabulary in three clicks or less and within 4 seconds. Efficient			
Navigate to their desired category in under 5 seconds. Efficient			

Build a sentence of their choice and present it to the communicative partner in under 10 seconds (for level 4)/ 5 seconds (levels 1 to 3). Efficient			
Clear the sentence strip in under 3 seconds. Efficient			
Can undo an error in 5 seconds. Efficient			
Focuses on the vocabulary as opposed to the background colour of the interface. Engaging			
Are users attracted to the interface? Engaging			
Are users engaging with the App? Engaging			
Buttons are distinctive and the function of each button is clear. Error Tolerant			
The language used is simple and appropriate /familiar to the user. Error Tolerant			

Any errors occurring within the App? Error Tolerant			
Each child is given a demonstration of the App by a staff member familiar to them. Easy to Learn			
Independent use of the camera feature. Easy to Learn			

Appendix OO: Letter to Principal and Teacher re: Suspended Observations

Dear [principal],

As you are aware one of the children taking part in my research is experiencing personal difficulties at this time. I have spoken with my supervisor and we feel that it would be unethical and unjust to the child if we were to carry out another two observations. The other child in the class is also a participant of the research; however, we feel that my presence to conduct observations with that child may impact on the other. Therefore, I am proposing that we suspend observations with these two children.

I will still be including them in the research and I will be requesting feedback from the classroom teacher in the final week so as to triangulate data already gathered. However, I feel that if we were to continue with observations we would be breaching our duty of care. I do not want to cause unnecessary stress to the children and I feel that there would be a risk of doing so if I continued observations with them.

These two children have been very valuable to the research and have shown great potential for the use of these types of devices and Apps; however, now may not be the right time for them. I would be grateful if you would discuss this with Shane to seek his approval on this matter.

Kind regards,
Miriam O' Sullivan,
U214 Post-Graduate Research Office,
North Campus,
Institute of Technology Tralee.

Appendix PP: Email from Speech and Language Therapist

Email received from Speech and Language Team post-intervention

Miriam,

You must be delighted that this is coming to a close. I am afraid you should not be thanking us as we have had relatively nothing to do with the devices since they came into use, unfortunately so. I have seen some of the children use the device in ASD 2 but other than that our workload has not allowed us to participate too much and therefore I do not feel I can complete these questionnaires. Apologies for that. Well done though and please let us know how you got on.

Appendix QQ: Participant P.E.C.S. Feedback