The Design of Multimedia-Based Instruction to Support the Academic and Social Development of Children with Autism

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Declaration

I hereby certify that this material, which I now submit for assessment on the programme of study leading to the award of MSc. in Computing, is entirely my own work and has not been taken from the work of others save and to the extent that such work has been cited and acknowledged within the text of my work.

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Abstract

This investigation explores the design of a multimedia-based lesson to enhance the social skills development of young learners with autism. Both interface and web accessibility guidelines are assessed throughout the implementation of the prototype, with particular attention given as to how these guidelines can be improved upon to meet the cognitive needs of our target audience. The Triad of Impairments are a set of common traits that learners with autism exhibit. These include: impairment in social communication; impairment in social interaction; and impairment in imagination. Software designers and researchers are more recently turning to computer-based learning technologies to provide support for these learners.

An in-depth requirements analysis study was conducted in local special needs and autism classrooms, in order to create a user profile and design model for the prototype lesson. This 'user-centred' design approach was then implemented throughout all phases of prototype development. Thorough evaluations were conducted with tutors and expert users at each stage. During the final phase of development a nationwide online evaluation was conducted with special needs schools in order to consolidate findings.

It is concluded that this software could be incorporated into current autism classroom curriculums. The theme of the lesson has an original approach for teaching self-help skills to these young learners. The clear, clutter-free and simple navigation makes the software easily accessible. The additional features of quizzes and Flash games (reinforcers) have been judged as an effective approach for encouraging and rewarding learning.

A nationwide survey was conducted to consolidate the design structure of the prototype. A random sample of Irish national special needs schools was chosen to participate in the survey. The survey has resulted in positive findings regarding the prototype lesson's interface design, accessibility features, computer-based learning support and multimodal components. It is anticipated that these guidelines will contribute to a software design framework that can be used to generate further social scenario lessons.

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List of Abbreviations

ABA	Applied Behaviour Analysis
ARCS	Attention Relevance Confidence Satisfaction
ASD	Autistic Spectrum Disorders
ATAG	Authoring Tool Accessibility Guidelines
ATRC	Adaptive Technology Resource Centre
BACB	Behaviour Analyst Certification Board
CDC	Centers for Disease Control and Prevention
CSS	Cascading Style Sheets
CVE	Collaborative Virtual Environment
DSM	Diagnostic and Statistical Manual for Mental Disorders
DTI	Discrete Trial Instruction
DUID	Detailed User Interface Design
HCI	Human Computer Interaction
HTML	HyperText Markup Language
ICAN	Interactive Collaborative Autism Network
NCCA	National Council for Curriculum and Assessment
NDA	National Disability Authority
PECS	Picture Exchange Communication System
SDS	Screen Design Standards
SMIL	Synchronized Multimedia Integration Language
SVE	Single User Virtual Environment
ToM	Theory of Mind

UAAG	User Agent Accessibility Guidelines
VE	Virtual Environment
VLE	Virtual Learning Environment
W3C	World Wide Web Consortium
WAI	Web Accessibility Initiative
WBI	Web-Based Instruction
WCAG	Web Content Accessibility Guidelines
XHTML	Extensible HyperText Markup Language
XML	Extensible Markup Language

1. Chapter One: Introduction

1.1 Introduction

Autism was first documented in 1943 by Leo Kanner, an American psychologist (Kanner, 1943). Until recently, autism was seen as a rare condition, with relatively few children being diagnosed with the disorder. However, more recently, The Centers for Disease Control and Prevention (CDC) have reported that the diagnosis of young children with autism is fast on the increase (CDC, 2007).

A model of three impairments, more commonly known as The Triad of Impairments, has been created by researchers in order to identify key components of autism (Wing and Gould, 1979; Wing, 1993). This triad attempts to describe and understand how these children relate to people and the world around them. The three parts which make up the triad are:

1. Impairment in Social Communication.
2. Impairment in Social Interaction.
3. Impairment in Imagination.

A person is usually said to be on the autistic spectrum when he demonstrates characteristics of all three aspects, however an individual can be affected differently by any single element of these features.

Unsurprisingly, having any one of these characteristics could leave a person feeling isolated, alone and unable to form meaningful relationships with another individual. Many studies have been completed to try and overcome these impairments, and to provide support for social development. As computers are increasingly becoming the

central tools used in communication and education, researchers and developers are turning to computers to provide support and answers to overcome these impairments.

1.2 Research Aims

This research project creates a multimedia-based software program to support and enhance the educational and social development of young learners with autism. A fully functional animated prototype is developed which can be used in both classroom and home environments to assist social skills development.

The prototype is developed according to web accessibility guidelines such as the Web Accessibility Initiative (WAI) current standards (WAI, 2006). These guidelines are investigated thoroughly with a strict focus on how to improve upon them during interface design to meet the accessibility needs of learners with autism.

These research aims have led to two research questions which are addressed during this study:

1. Is there evidence to suggest that a multimedia-based instructional program can be developed which can assist in the social development of the young learner with autism?
2. Using the framework of the developed prototype, what are the criteria for improving on the existing industry guidelines for web and software accessibility in relation to the user with autism?

1.3 Research Objectives

The research objectives for this study are as follows:

- To create a user profile of the child learner with autism and use this model as a basis for developing a multimedia-based instructional lesson.
- To consult, and evaluate the user model, with tutors during development phases.
- To develop a multimedia-based instructional prototype that incorporates the use of social routines as a software learning environment to support the social and educational development of learners with special needs. The software must include a special emphasis on relevant accessibility issues.
- To liaise with tutors and learners during development of the prototype and encourage the tutor and learner to test and evaluate the prototype, thus incorporating a 'user-centred' design approach.

1.4 Chapter Outlines

Chapter Two: Literature Review, explores the research conducted into the traits and characteristics of autism particularly in relation to social skills development. Autism, computer-based learning environments and software, along with interface and web accessibility guidelines are also presented.

Chapter Three: Investigating the Learner Profile describes investigations into the learners' requirements and early interface design evaluations in order to create the user-profile.

Chapter Four: Accessibility and Usability in Lesson Development, documents the design approach of the software lesson. This chapter highlights the step-by-step, user-centred design approach focusing on tutor evaluations and recommendations. Prototype revisions are also depicted addressing the tutors' feedback.

Chapter Five: Prototype Evaluation, details results from the nationwide prototype evaluation conducted with special needs and autism schools.

Chapter Six: Conclusions, discusses the conclusions that were attained from completing this research and outlines future recommendations for social skills software development.

2. Chapter Two: Literature Review

2.1 Background to Autism

According to recent findings released in 2007 by the *Centers for Disease Control and Prevention (CDC)* as many as one child out of one hundred and fifty in the eight year old age group are now being diagnosed with Autistic Spectrum Disorders (ASD) in the United States (CDC, 2007).

Alarmingly, a comparison conducted by the American Department of Education concluded that there has been a 172.86 % change in the number of children diagnosed with ASD in the 1990s (US Department of Education, 1999).

In accordance with these findings it is not surprising that there is an increase in demand for user-friendly, productive and accessible educational software. Studies show that learners with autism require a '*specialist education'* in order to *'maximise their skills'* (Coventry University, 2007). However, in order to gain a clear and concise understanding of user requirements it is necessary to acquire knowledge and awareness of the learning styles of children with autism.

2.1.1 Learning Styles

Numerous learning style models for normally developing children have been proposed, mostly deriving from the following three modalities: visual learning (learning through seeing e.g. pictures, diagrams); auditory learning (learning through hearing e.g. sounds); kinaesthetic learning (learning through doing or touching e.g. smell) (Felder and Silverman, 1998; Litzinger *et al.*, 2007).

Generally, children especially in their very early months, have an instinct to acquire a preference to the kinaesthetic style of learning. Their absorption of knowledge is through direct physical contact, exploration, and touching of objects. As children continue to grow and develop independently so does their learning style. Even though the home environment is the primary area to which children are accustomed, children can show a preference to learning styles, which differ to that of their parents. It is also not unusual for children to use different learning styles in order to suit different circumstances (University of Illnois Extension, 2009).

With regard to special needs learners, research conducted into the characteristics and learning styles of children with autism illustrates that these children typically are stronger in the use of their visual skills as opposed to their auditory skills. Also, children with autism, sometimes show difficulty processing incoming information. Studies show that the brain's function of taking information in, storing information and retrieving this information is significantly different to normally developing children (Stokes, 1999).

This creates a number of outcomes on the child's development socially and educationally, most significantly in speech and language development. Children with autistic spectrum disorders find it difficult to learn and master language. Words, phrases and grammar all can prove daunting for young children. Integrating the learnt language into speech used in everyday social situations can be a difficult task. However, the use of graphics on computers or picture cards can provide a link or bridge, which can take advantage of a child's visual skills in order to teach a word or phrase (Howlin, 1998; Siegel, 2003).

2.1.2 Applied Behaviour Analysis

Applied Behaviour Analysis (ABA) is a technique, that is commonly used, which can provide support to a child with autism to learn especially in the area of speech development. The Behaviour Analyst Certification Board, (BACB), (BACB, 2009) describes Applied Behaviour Analysis as follows:

> *'...the design, implementation, and evaluation of instructional and environmental modifications to produce socially significant improvements in human behavior through skill acquisition and the reduction of problematic behavior. A behavior analysis program shall be based on empirical research, include the direct observation and measurement of behavior, and utilize antecedent stimuli, positive reinforcement, and other consequences to produce behavior change'* (BACB, 2009).

Applied Behaviour Analysis can be described as a framework, which examines the science of human behaviour and then uses its findings to improve behaviour, stop behaviour or teach a new behaviour. ABA provides a learning structure for children, which breaks down learning into a small step-by-step process. Methods such as drills, repetitive exercises and rewards are used to motivate learning (Wallin, 2004).

2.1.3 Discrete Trial Instruction

A component of ABA, which is primarily used in teaching children with autism, is known as the Discrete Trial Instruction (DTI). This is a one-to-one, adult-to-child method of learning, which uses small repeated steps in order to teach a task. The DTI method is composed of three major components: The Antecedent (the request or instruction from the teacher); The Behaviour (the learner's response to the instruction); and The Consequence (the reinforcer) (Desrochers *et al.*, 2002).

There are various types of DTI programs, which can cater for different needs and skill development of the student's cognitive, communication, play, social and self-help skills. The school curriculum can be customised to meet the learner's needs. The learner should choose reinforcements before beginning the program. Small snacks or short games are generally good reinforcers as they do not distract from time spent on training. Positive praise and reinforcements are used to reinforce correct skills, whereas incorrect skills are ignored (Autism Spectrum Institute, 2009).

An important feature of DTI is data collection. The tutor collects information about skill levels and problems incurred by the pupil. The tutor can then use this data to create a framework of the lesson. The Interactive Collaborative Autism Network, (ICAN), (ICAN, 2000) describes this five step structure which breaks down each lesson:

- *Discriminative Stimulus (Cue, Instruction, Command to Attend)* – This is the direction given to the learner from the tutor. The instruction should be clear, easy to understand and short.

- *Prompt (P) (Physical Verbal Model)* - The prompt is a planned interaction from the teacher to help the student answer correctly. In order to prevent the learner becoming dependant on the prompt, the prompt should be changed or removed when the learner answers correctly.
- *Behaviour (B) (Response, Command to Perform)* - The behaviour is how the learner responds to the direction. The learner should complete the direction correctly.
- *Stimulus Reinforcer (SR) (Consequence, Feedback)* - The stimulus reinforcer is the feedback given to the learner after a given response, either positive or negative. If the learner answers positively without a prompt, a positive reinforcer is provided to the learner. If a negative response is given by the learner, then the tutor follows a pre-planned sequenced pattern for correcting the wrong response by the learner. This should encourage the learner to answer the correct response independently.
- *Inter-Trial Interval (ITI) (Presentation, Wait Time)* – Inter-Trial Interval is a five second interval between trials. This provides information to the learner that one task has been completed and the next is going to begin.

According to ICAN (2000) the time limits and sequences of these lessons can vary in order to meet the requirements and skill levels of each individual learner.

The overall goal of DTI is to enable each learner to develop skills to be used in their everyday lives as independently and successfully as possible. Even though research has shown DTI to be an effective way of teaching language skills, it usually has to be combined with other methods of teaching and learning so the learner can transfer and

integrate these skills into his own social setting (Association for Science in Autism Treatment, 2006).

2.1.4 Social Skills Development

Dr. Temple Grandin (1995), a recognized author and speaker on the subject of autism, describes how her own thoughts are symbolised through different pictures and sequences of images.

> *'I think in pictures. Words are like a second language to me. I translate both spoken and written words into full-color movies, complete with sound, which run like a VCR tape in my head. When somebody speaks to me, his words are instantly translated into pictures.'* (Grandin, 1995).

Children with autism can experience problems in the area of social understanding. Howlin (1998) states that the social impairment in autism can have an impact on different areas of a child's performance no matter what level of intellect the child possesses. Children with autism can seem to have a lack of social interest or social awareness. It can almost be difficult to imagine how a child with autism can be taught social skills without having any level of social understanding (Jordan and Powell, 1995).

Children with autism can have difficulty in comprehending different mental states i.e. an understanding that people around them also know or believe things (Baron-Cohen *et al*., 1985). This is otherwise known as the 'Theory of Mind' (ToM). Different aspects of

research in recent years consist of a focus on the 'Theory of Mind' (ToM) hypothesis in order to teach an understanding of social routines to young children with autism (Peterson *et al.*, 2007; Tager-Flusberg, 2007). An experiment using puppet dolls and marbles known as the 'Sally-Anne False Belief Task' carried out by Baron-Cohen *et al.* (1985), concluded that a deficit in cognitive behaviour exists in the child with autism which may be connected to social impairment.

The use of pictures or photographs can be a very effective technique used in a system in order to assist in the educational needs of the learner. Pictures can overcome a broad spectrum of deficits. Pictures do not impact a heavy cognitive load on the learner. Imagery can also be used as a substitute to overcome different language barriers, and it does not require a strong utilisation of memory (Howlin, 1998).

2.1.4.1 Picture Exchange Communication System

The Picture Exchange Communication System (PECS) (Bondy and Frost, 2001), is a method of encouraging communication in non-verbal children. Objects in the child's environment such as drinks, food, games and art materials are represented as picture cards and attached to a board using velcro. When the child requests an item, the child is encouraged to place the picture card into an adult's hand, as opposed to pointing at the object. This prompts the child to interact with the adult. Also, the adult can use the cards as a means of teaching sounds and words to the child. When a child demonstrates a regular attempt at pronouncing the word on a particular card, the card can be removed.

The removal of the card serves to encourage the child to use the phrase instead of becoming dependant on the card (Bondy and Frost, 2001; Siegel, 2003)

Dr. Temple Grandin, (well-known author and speaker on the subject of autism introduced earlier), describes how her own thoughts are symbolised through different pictures. When a word or phrase is spoken she creates a mental model which associates the word with a picture (Grandin, 1995). As we already know from the literature, children with autism have a preference towards a visual style of learning. Studies by Baron-Cohen *et al*. (2002) used a concept of photographs-in-the-head to teach children with autism mental states by extending these concepts into cartoon thought-bubbles. The use of the thought-bubble was to depict what a person was actually thinking. Six stages were used in order to test the theory using different methods. The test results show that children's understanding of mental states improved through the training. It was also found that the-picture-in-the-head strategy increased the children's understanding of false belief. Overall, the use of the pictorial speech worked as an advantage in teaching the child.

2.1.4.2 Social Stories

Social Stories are a set of guidelines composed together as a mini story in order to teach social skills to young learners with autism or other learning disabilities. The stories, originally developed by Gray (Gray and Garand, 1993), an educational consultant, are used to prepare a child's understanding for upcoming events by highlighting key points

of the event (Wallin, 2004). Each story seeks to answer problematic questions such as: '*what is happening? ; why is it happening? ; or who is doing what?*' (Smith, 2003, 3).

The stories can be used in order to prepare a child for different occasions such as a trip to the supermarket, a visit to the dentist or even to teach a new social skill like how to wash one's hair. It is best to introduce the story as part of a child's everyday routine. When the child begins to show improvement from listening to the story daily, the use of the story can be gradually lessened. However, if the story does not have an influence on the child's behaviour, the story may need to be redrafted or reworded (ICAN, 2000).

Social stories are a successful educational tool currently used through the means of videotape, book, flashcards and comic strip (The Gray Center, 2009). Howley and Arnold (2005, 95) state that a computer-based and visual approach for representing Social Stories could have a motivational effect on learning. Previously Hagiwara and Myles (1999), made the first computerised Social Story attempt through the use of Hyper Cards. The results of this graphical and text onscreen approach proved positive.

From the literature, it has been described that the use of pictures and symbolism has shown a significant impact on improving a child's communication skills. The approach of using pictures as an educational tool is effective, as it works on the learner's visual style of learning and is a solid method that the learner can relate to (Howlin, 1998; Bondy and Frost, 2001). The concept of social stories has been adopted as an instructive technique, and is currently used by educators and parents in order to teach social skills to young learners with special needs. These miniature instructional stories have adapted a form similar to the methods used by the discrete trial training. Stories are composed of short step-by-step instructions which describe a given situation to the young learner.

Through a combination of two successful areas, pictures and social stories, there is scope to suggest that these areas combined can further increase the social development of young learners with autism.

2.2 Technology Context

In more recent years there has been an increase in research into technologies that may encourage children with ASD to develop both socially and emotionally. The Diagnostic and Statistical Manual of Mental Disorders (DSM) describes the impairments associated with autism (DSM-IV^{TM}, 1994):

- Children with autism experience difficulty forming relationships with their peers.
- The use of expressive and non verbal actions such as eye contact with their peers can also be confusing for children with autism.
- Facial expressions and the use of hand gestures during verbal conversation is another feature which children with autism experience difficulty in comprehending (DSM-IV^{TM}, 1994).

Generally children with autism exhibit problems with imaginative behaviour, and as a consequence children will often possess difficulty in playing especially with other children. Children with autism can also develop an obsession or fixation with objects or parts of objects like watching a tumble dryer spin (DSM-IV^{TM}, 1994).

It has been observed that children with autism have shown difficulties in expressing and controlling their emotions. Children with autism do not only have problems with their own emotions, they also show a misunderstanding in observing the emotions of others around them (Loveland, 2005). Sometimes children with autism can misinterpret that they should change their own emotional behaviour in order to suit the current situation. Their display of affection can also seem robotic or unnatural, and in certain circumstances, it can almost be perceived as a *'..learnt sequence of behaviour'* (Loveland, 2005). Children may also need a prompt from parents or a teacher in order to act affectionately in a particular situation.

From previous research conducted, observations have shown that children with special needs prefer to '*...communicate with and through computers'*. Computers are a conventional method for children to work independently and a place to be in control (virtual environment) as opposed the '*...outside chaotic social world'* (Moore *et al.,* 2000). The use of virtual environments as communication tools is discussed next.

2.2.1 Virtual Environments

The concept of a virtual environment is a motivating area within the computer world. Recent developments in virtual environments have shown major influences on the education of children with ASD. These environments have also given children a safe and basic setting in order to explore and control their own emotions and social behaviours, as opposed to the chaos and confusion that children sometimes find in

reality (Strickland, 2003). Two types of virtual environments (VE) can be defined i.e. single user *SVE* and multi-user *CVE*.

A Single User Virtual Environment (SVE) is a computer-based virtual environment where users interact with pre-programmed virtual objects or avatars. This type of environment is best suited to novice users of VEs. Learners with mild or moderate autism who may not yet feel comfortable communicating with others could find this environment useful as interactions with other users is at a minimum (Kerr, 2002). The *Puddingstone Place* autism software provides an interactive SVE where learners with autism can navigate and explore items in the home setting at their own pace (Children's Hospital Boston, 2006).

A Collaborative Virtual Environment (CVE) can be described as a '*computer-based, distributed environment in which people can meet and interact through the use of avatars'* (Moore *et al.*, 2005).

A study conducted by Moore *et al*. (2005) was used to demonstrate the effectiveness of CVEs and avatars on the social development of young children. Each avatar consisted of a 3-D Model, which displayed a facial expression demonstrating different emotions: happiness, fear, anger, surprise, sadness, and disgust. A number of different situations and exercises were presented to the users. The users then had to demonstrate a response through the use of the avatars. Findings from this study suggested that a virtual environment has a potential of building social awareness for children. The use of avatars is less threatening as opposed to face-to-face communication with people, and a child can show his own feelings and emotions through the avatar (Moore *et al*., 2005).

2.2.2 Avatars and Virtual Messengers

Moore *et al.* (2005) brought the avatars to another level and applied them in their creation of the Virtual Messenger. This application allowed for the exercise of dialogue between two or more people. The use of the avatars was developed further and the learners in dialogue were encouraged to use the avatars to represent and emphasise feelings throughout the discussion.

Moore *et al.* (2005) summarized a number of benefits observed from the above exercise and the impact that its use can have on children with autism. The implementation of a virtual messenger can potentially help children with autism that do not wish to engage with, or fear coming face-to-face with, another person. However, they would like to partake in dialogue with others e.g. in relation to an interest or hobby.

The use of the virtual messenger can offer a means to children to communicate with others instead of leaving them with a sense of isolation. The CVE and Virtual Messenger can also provide a safe, practice environment. It can give the child a chance to overcome his autism–specific deficits through providing a chance to practise events forthcoming in the real word. The technology also provides an attempt to overcome the Theory of Mind (ToM) deficit by providing children with a foundation to express their own emotions, and relate to others, through the use of the avatar (Fabri and Moore, 2005).

2.2.3 The Transporters

A recent project commissioned by the UK government, based on ideas of Baron-Cohen, was the creation of cartoon vehicles containing the faces of real human actors attached to the front of the vehicles. As described by Baron-Cohen, children with autism are often strong *'systemisers'*. They are attracted to predictable systems such as rotating fans and wheels. Systematic vehicles such as trams, cable cars and ferries were used to hold the children's attention (Baron-Cohen *et al.*, 2007). The aim of the project was to focus children's attention on facial expressions in a concealed manner so the child is unaware that he is attentively looking directly at another face. The project uses aspects of the Discrete Trial Instruction, so the use of repetition within the program reinforces an understanding of emotion and social interaction.

Even though the results above show a great amount of potential, there are concerns that the exploitation of computer resources could actually enhance social withdrawal and encourage obsessive behaviour (Bölte, 2006). However, if the use of technology is timetabled and supervised as part of a child's everyday classroom routine, the results can have a positive outcome on the child's development.

The majority of current classroom environments still rely on paper-based means as a technique for learning. The student is mostly dependant on the teacher or tutor to deliver the lessons. In some classrooms where the learner has a limited amount of verbal skills, the PECS system described earlier (Bondy and Frost, 2001), is used as a method of pupil and teacher interaction.

The use of a computer-based lesson solution incorporated within the everyday curriculum, can add some variety on lesson input for the learner. The technology also can provide a level of independence to the learner, so the learner is not fully dependant on the teacher to provide learning. Depending on the technology, the learner can be provided with control over the lesson, by being given the freedom to pick or choose his lesson. Overall, the use of technology can have an encouraging impact on providing education to the learner with special needs.

2.3 Learning and Motivational Theories

2.3.1 Introduction

The design of any online learning application requires an understanding of the users' learning requirements. A triad of three areas combined are discussed within this chapter, i.e. how people learn, what motivates people to learn and how the web can facilitate these learner requirements.

2.3.2 Multiple Intelligences

The Multiple Intelligences theory was proposed by Gardner in 1983. Originally Gardner proposed eight intelligences which adults and humans can possess (Gardner, 1999). These are listed as:

- Linguistic Intelligence
- Logical-Mathematical Intelligence
- Musical Intelligence
- Bodily-Kinaesthetic Intelligence
- Spatial Intelligence
- Interpersonal Intelligence
- Intrapersonal Intelligence
- Naturalist Intelligence.

Many schools focus lessons around the linguistic and logical-mathematical intelligence. According to Armstrong (2000) many children who have preferences towards the other styles of intelligences such as musical or bodily-kinaesthetic, can often have their talents dismissed within the classroom. Many of these learners are regarded as 'special' or 'ASD' instead of having their talents acknowledged or encouraged (Armstrong, 2000).

2.3.3 ARCS Model

One of the outcomes of this research will be an educational software prototype that is web-enabled. We therefore examine appropriate theories that could underpin the instructional design approach to lesson development. In order for a learning environment to be effective, motivational influences must also be considered from the early design phases. Siegel (2003) states that a young child with autism is more motivated to please himself, as opposed to pleasing others around him. Thus it is

important to capture and maintain the child's attention in order for learning to be effective. The researcher must design different elements within the program effectively in order to captivate the learner's interest. This in turn, shall stimulate the learner to acquire knowledge from the lesson and provoke the user to recall the information in different situations. The ARCS Model was designed by Keller as a method of overcoming motivational obstacles in the design phase of learning environments (Keller, 1987; Keller, 1996). The headings under which Keller proposes motivational aspects are attention, relevance, confidence and satisfaction as seen in Table 2-1.

Table 2-1 ARCS Categories (reproduced from Keller, 1987)

Attention	Relevance	Confidence	Satisfaction
Incongruity, Conflict	Experience	Learning requirements	Natural Consequences
Concreteness	Present Worth	Difficulty	Unexpected Results
Variability	Future Usefulness	Expectations	Positive Outcomes
Humour	Need Matching	Attributions	Negative Influences
Inquiry	Modelling	Self-Confidence	Scheduling
Participation	Choice		

Attention

Most importantly, the learner's attention must be attracted and maintained in order to get the learner motivated and involved in the software. Keller (1987) states that the main aim in order to engage a user's interest, is to find a medium between boredom and hyperactivity. Different methods included in column 1 of Table 2-1 above can be integrated, such as humour i.e. using humorous explanations or summaries to describe a topic. Variability can also be incorporated through different varieties of media, such as video, animation or audio to draw the learner's attentiveness.

Relevance

Familiarity is key at this phase as it is good to draw on examples from skills already possessed by the learner or his past experiences. It is important to give the user control and choice for accessing the information, and to use relevant and clear choice of language (Keller, 1987).

Confidence

The learner's confidence can be increased by encouraging the learner of the likelihood of his success. The learner should be provided with regular feedback about the successful outcome of his learning. Learners should be provided with a level of control over their lessons and assessments. The level of difficulty of a task should be increased with each step (Keller, 1987).

Satisfaction

Satisfaction can be promoted by providing the learner with positive feedback and information about the success of the learning outcome. The learner should be praised

on completion of new or difficult tasks. The learner should not be patronized by providing praise for very simple tasks (Learning Theories Knowledgebase, 2008).

It is important that the different elements of the ARCS model are valued by both the researcher and teacher alike in order to retain the interest of the child with special needs. During the design and development phases of the software cycle (documented during the methodology phase), the categories within the ARCS model are referenced in order to ensure that the learning environment within the program is motivational. Teachers and tutors should also consider the specifications of the ARCS model within their own teaching curriculum. From the perspective of this research, the ARCS model can work in collaboration with the Discrete Trial Instruction. The use of reinforcements (i.e snacks or toys) can be incorporated in the training in order to increase the confidence and satisfaction levels of the learner with autism. In the case of software the reinforcers are more likely to be screen-based.

2.3.4 Using Web-Based Instruction

Web-Based Instruction (WBI) can be described as a means of providing instructions to a remote audience using the web as a medium (Kahn, 1998). An instruction is a method of formatting and organizing data in order to provide maximum transfer of information from teacher to learner. The design framework of instruction involves the use of instructional theories and design models (Dillon and Zhu, 1998). The instruction provides the learner with a basis to learn, by providing an opportunity for the learner to interact. The instruction may also provide different responses to the learner, which can

encourage and improve the learning experience. A system of different components such as software, graphics, video, search–engines and audio are integrated within the WBI structure in order to make learning more effective. Other tools such as email, forums, messenger tools and online conferencing methods provide a means of interaction with other learners. In the case of learners with autism, an appropriate subset of these features may be included.

2.4 Interface Design and Usability Guidelines

2.4.1 Introduction

Many computer experts have commented upon techniques or have proposed guidelines as to how a computer interface can be made more accessible and user-friendly. This section investigates these guidelines in order to propose what best suits young learners with autism.

2.4.2 Usability Characteristics

Usability can be described as the measure of how easily a user can learn how to use a system or piece of software. It is also a measure of how effective the system and software is at completing tasks for the user (Feldstein and Neal, 2006). The design of a usability framework for software is essential in order to obtain user acceptance of the product (Shneiderman, 1998). There has been much work completed on principles and

standards in order to support usability. Usability can be broken down into the following characteristics (Preece *et al*., 2007):

- *Efficiency*: In order for software to be efficient the user should be able to manipulate the package and complete a task without requiring too much effort or completing too many steps.
- *Effectiveness*: Effective software should be able to carry out its main aim or goal.
- *Safety*: The software should be user-friendly and safe to use. It should consist of a safe environment so that users can explore the software without making critical mistakes. The software should also include reversible options, such as undo, so that unwanted mistakes can be reversed.
- *Utility*: Software should also contain all the appropriate functions in order for the user to complete his task.
- *Learnability:* Software should be easy to learn. Users should be able to use the software efficiently without having to spend an excessive amount of time learning functions.
- *Memorability*: The software should be easy to remember so that even if it has not been used for a couple of months, users should not have to re-learn how to use the whole package.

Extra attention should be given to each of these characteristics to meet the cognitive and motor accessibility requirements of learners with special needs.

2.4.3 Interface Guidelines for Computer-Based Learning Environments

Designing the interface is an important phase of any software design. The usability characteristics mentioned above (Preece *et al.*, 2007), should be included within all features of the design. When developing e-learning technologies for learners with special needs, extra considerations for both accessibility and learning support need to be moulded with standard design guidelines.

A number of interface design guidelines have been proposed by Jones and Okey (1995) in order to assist in the development of interface design of computer-based learning tools. From the literature, research in this area has shown that the design of the interface should be considered early in development i.e. the design phase of the software lifecycle (Mayhew, 1999). The guidelines have been categorised to focus on different concepts within interface design. For completion of this research these guidelines are adapted to the learning requirements of young children with autism.

- *Provide access for all types of media in the same manner:* The same controls should be used to access all different media within the software. The access method should also be kept consistent. If an icon is used to access video then an icon should also be available to access text. Young learners with autism are not fond of change, and so have a need for sameness. By maintaining a consistent method of controls throughout the software the young learner can adapt more effortlessly to the software (Cumine *et al*., 2000).
- *Use similar control icons for all types of media:* It is recommended to keep control icons consistent throughout the software for different media such as

audio and video. Also, it would be beneficial to make use of universally acknowledged symbols such as the play and pause control on a television remote control (refer to Figure 2-1). This prevents overloading the young learner to learn new controls. It also provides the young learner with a sense of familiarity. Predictability and routines are key assets in assisting the learner with special needs to use the software independently. Users with special needs create connections between objects or symbols which are meaningful to them. It is important to use universal symbols as a means to avoid unnecessary confusion for the learner (Peeters, 2000).

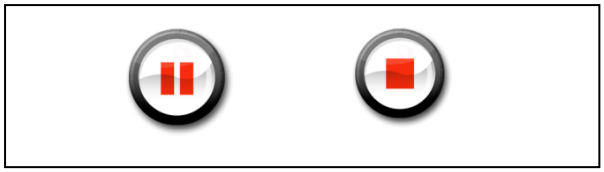


Figure 2-1 Buttons indicating pause and stop symbols

- *Provide organizational cues such as maps and menus:* The use of site maps and drop-down menus provides an overview of the software. This can allow for straightforward navigation within the software. Site maps usually show a breakdown of software content so users know exactly what information is available (Tidwell, 2005).
- *Provide users with information to let them know where they are in the program:* The use of appropriate headings and titles can provide the user with an indication of where they are in the program. Categorised colour backgrounds

and borders or icons can also provide information to the learner as to his location within the system. This is particularly appropriate for the learner with autism. Young learners sometimes show a preference for visual learning, so the use of colour and graphical icons can guide the learner using the software. According to Howlin (1998) symbols or pictures can have a positive outcome when used appropriately within the learning environment as they have '*…few demands on the child's cognitive, linguistic and memory skills…*'.

- *Use location indicators to let users know where they are, where they need to go, and how long it will take them to get there:* The use of location indictors such as page or section numbers or graphical guides are recommended to indicate to the user how many steps are involved in a particular section and how far they have progressed. This approach can prepare the young learner with ASD for what he can expect to encounter in each step, and the length of each section. Users with special needs develop preferences for set routines. It is important for the learner to be prepared and have a prior understanding of the steps involved. The learner with special needs can become very upset or agitated if there is even a slight change made to his routine (Jordan and Powell, 1995).
- *Use appropriate styles and text for certain types of data. Choose specific fonts, font sizes and font characteristics to represent certain types of information:* The use of different font formats is recommended in order to aid the learner to complete a search on the document. The use of different headings and formats can be helpful. For example bold is good at attracting the user's attention to specific key words. Special consideration of fonts is also recommended to assist in the readability of the text for the young learner. Walker and Reynolds (2000)

found in their study of screen design for children's reading, that the presentation of text and information is an important aspect in the visual design of any given screen.

- *Provide users with immediate descriptions of program controls on the same screen as the control.* Advice or help options to assist in use of controls should be readily available on the same screen. Learners should not have to click through a series of other screens in order to gain assistance. Additional assistance can be provided as a pop-up window which the cursor activates. An interface agent can also provide for this functionality (Mandel, 1997). This can prevent user frustration as help is provided immediately for the young learner.

These seven guidelines are not a strict set of rules which should be implemented, but they are a set of specifications which can be referred to in order to steer the interface design in the right direction (Jones and Okey, 1995). It is important to remember that any of these guidelines which are implemented in a given interface should be carefully considered and tested with the user during and after the design and development phases.

2.4.4 Shneiderman's Eight Golden Rules of Interface Design

Shneiderman (1998) recommends a concise set of guidelines that can be referred to, manipulated or used to validate the design of the interface. These guidelines should be adhered to in order to make the interface as user-friendly as possible. Shneiderman's guidelines can be used in combination with Jones and Okey's (1995) learning

procedures to provide for a more robust screen design framework. We now provide a summary of Shneiderman's eight guidelines (Shneiderman, 1998):

- *Strive for consistency:* Menus, colour, layout, fonts and help menus should be consistent throughout the screens.
- *Enable frequent users to use shortcuts:* As users become more familiar with the software special keys, macros and hidden commands should be available to the user in order to speed up interactions.
- *Offer informative feedback:* Users' actions should result in a relevant amount of feedback. Minor feedback should be provided for frequent actions, and more substantial feedback should be provided for more infrequent actions.
- *Design dialogues to yield closure:* Actions should be divided into a series of sequences. Feedback should be provided to the user on the completion of a task.
- *Offer error prevention and simple error handling:* Software should be designed so that users cannot make serious errors. If the system does detect an error made by the user a set of simple and specific steps should be provided by the system in order to undo the error. This is particularly important for learners with ASD. The use of simple error handling techniques can avoid unnecessary frustration or confusion for special needs learners.
- *Permit easy reversal of actions:* Users should be able to reverse undesired actions using a single step or through a group of actions.
- *Support internal locus of control:* Experienced users like to feel in control of the system. Unexpected system actions or tedious data entry should be avoided in

order to prevent user dissatisfaction. This avoidance of unnecessary work can alleviate dissatisfaction for special needs learners.

- *Reduce short-term memory load:* Displays should be kept simple. Splitting of information between different windows should also be avoided. Additional help or information should be readily available online. By reducing the work in short-term memory, there is less strain on the cognitive load of the learner. This is especially required for the young learner with autism to avoid unnecessary strain on memory.

Yet again, each of these points if implemented appropriately during screen design can alleviate unnecessary cognitive strain for young learners with ASD. This can allow the learner to have more freedom and feel at ease when exploring software.

2.4.5 Norman's Seven Principles for Transforming Difficult Tasks

Finally, we summarize Norman's (1998) seven principles for simplifying tasks. Even though these principles are more focused at tasks rather than screen design, they are considered important for providing an enjoyable user-experience for young learners with ASD (Norman, 1998).

- *Use both knowledge in the world and knowledge in the head:* Norman (1998) states that people learn easier when knowledge required for completing a task is available externally. However, when a user internalizes knowledge, performance can be faster. Users should be able to use a combination of the knowledge in the world and in their head in order to complete a task efficiently.

- *Simplify the structure of tasks:* The designer must consider the drawbacks and disadvantages of both short-term and long-term memory when creating a framework for tasks. Tasks should be designed using a simplified approach or re-modelled to prevent overloading the user's memory. As previously mentioned, this is an important feature to avoid overburdening the cognitive load of the young learner with ASD.
- *Make things visible:* Norman advises to show what is really happening. Provide complete images that match the user's mental model of the task in order to make performance and understanding easier.
- *Get the mappings right:* User actions should be compatible with user intentions e.g. the plus symbol (+) on the volume control should increase the level of sound.
- *Exploit the power of constraints:* Constraints should be used so there is only one possible way of completing a task. Again this is an important aspect for learners with ASD who like to follow a strict routine. These users can get confused with multiple unlinked steps or sequences.
- *Design for Error:* Gain an understanding of errors and create a design which prevents errors from occurring. Try to foresee which errors may occur and provide simple methods of correcting these errors.
- *When all else fails standardize:* When design depends on arbitrary mappings, standardize so the learner only needs to learn the method once, to use it effectively.

The design of tasks should not be taken lightly. The researcher should complete an in-depth task analysis with special needs learners to make sure all requirements are met.

2.4.6 Important HCI Elements for Users with Autism

During the design phase of the user interface it is important to facilitate the main requirements of the learner with autism while also taking into account the HCI principles proposed by Jones and Okey (1995), Shneiderman (1998) and Norman (1998). Learners with autism have a tunnelled focus and like to follow a strict routine. The following features should be included in any design in order to create an environment which can cater for a learner with autism (Murray, 2002):

- Reduced stimuli
- Visual cues
- Repetition
- Clear cut rules
- Lack of affect
- Structure
- Predictability
- Controllability
- Interest
- Unhurried pace.

According to Murray (2002) if these characteristics are included within all elements of the software design, a safe environment shall be created to allow for more independent learning.

2.4.7 Children and Web Usability

A study conducted by Nielsen (2002) in relation to children and web usability confirmed that features such as unclear or inconsistent navigation, difficult wording and lack of perceived clickability can also have a negative impact on children's web usability. Other findings also suggested that children preferred animation and multimedia and favoured pictorial navigation maps incorporated within the site. However, it was noted that children would often abandon a web page if it consisted of a lengthy scrollbar, or if the nature of the website was not targeted at their own specific age group (Nielsen, 2002).

2.4.8 ASD Software and Interface Design Recommendations

Taking into consideration the advice of the above referenced experts (Nielsen, 1993; Jones and Okey, 1995; Norman, 1998; Shneiderman, 1998) and recommendations of experts in autism (Jordan and Powell, 1995; Howlin, 1998; Cumine *et al.*, 2000; Peeters, 2000) it is important that priority be given to the HCI elements listed above, when implementing any design guidelines in order to meet the needs of the learner with special needs. Listed below is a summary of guidelines which should be prioritized when designing for learners with autism.

- *Simplify the structure of tasks*: Tasks should be designed in a structured and predicable format, avoiding cognitive overload of the users' memory. Learners with autism prefer a strict routine and need to be prepared for what is going to

happen next. The smallest change in the structure of a routine or task can cause a large amount of upset to a learner with autism (Cumine *et al*., 2000).

- *Design for Error:* The designer should test for common errors that learners can make in the system and should re-design the system in order to avoid these problems occurring. If the software cannot be re-designed, the designer must incorporate features to aid the user in overcoming the fault without causing unnecessary panic to the user. The system should provide relevant help through audio or visual means in order to assist the user with error recovery (Jarrett *et al*., 2005).
- *Strive for consistency:* Consistency should be incorporated at every level of the design approach. The look and feel of menus and buttons used to navigate around the software should remain the same throughout the software. The navigation system should be positioned in the same place and should also respond in the same manner when selected. The page layout i.e. font style and font sizes should remain similar through all the pages of the software (Dix *et al*., 2004).

  Reduce short-term memory load: Too much clutter on the screen should be avoided at all times. The elements visually available on the screen should be kept to a minimum so as to prevent overloading the learners' memory. Pictures and graphics should clearly represent what they are intended to symbolize, as opposed to the use of abstract graphics. Young learners with autism can find it difficult to create a connection between the abstract graphic and the object it is intended to represent. This can cause the user to become confused and frustrated (Howlin, 1998).

2.5 Web Accessibility

2.5.1 Introduction to the World Wide Web Consortium (W3C)

The World Wide Web Consortium (W3C) develops guidelines and principles which are compatible and interoperable throughout different platforms. The W3C aims to improve 'web operability', while also avoiding the exclusion of any users, technologies, hardware and software which has happened in the past (W3C, 2008).

2.5.1.1 The Web Accessibility Initiative

A feature of the W3C scheme is the Web Accessibility Initiative (WAI). The WAI (2006) creates standards and guidelines which can be incorporated into technologies to make them more accessible for learners with special needs. The WAI consists of three different components i.e. Web Content Accessibility Guidelines (WCAG), Authoring Tool Accessibility Guidelines (ATAG) and User Agent Accessibility Guidelines (UAGG). By following the guidance and standards outlined by the WAI it is intended that the interface and content developed in this research project will be highly accessible and navigable, and will provide a supportive educational environment.

Web Content Accessibility Guidelines (WCAG 2.0)

The Web Content Accessibility Guidelines 2.0 describe to developers how to design web content such as text, images, forms and audio more accessible to people with disabilities (WCAG 2.0, 2008). This set of guidelines has recently been updated from the original WCAG 1.0 (1999) guidelines. The WCAG 2.0 contains four principles:

perceivable; operable; understandable; and robustness, for designing web accessibility. Each of these principles has guidelines which are measured using conformance levels described below.

The inclusion of these four principles during the development of educational software should provide for easy access, for any user, to different types of web content.

Authoring Tools Accessibility Guidelines (ATAG 1.0)

The Authoring Tools Accessibility Guidelines (ATAG 1.0) defines a set of guidelines for authoring tools that enable developers to design accessible web content. These guidelines are developed in order to follow the principles incorporated in WCAG 1.0. The ATAG guidelines also incorporate rules so authoring tools can be accessed and used by users with disabilities (ATAG 1.0, 2000).

The ATAG 1.0 (2000) guidelines include twenty-eight checkpoints which specify the requirements for authoring tools to follow in order to satisfy each guideline. Each checkpoint includes one of three priority levels, which represents a level of importance for meeting the requirement of the specified guideline. The priority levels are as follows:

- *Priority One:* It is essential for the guideline to meet targets.
- *Priority Two:* It is important for the guideline to meet targets.
- *Priority Three:* It is beneficial for the guideline to meet targets.

These guidelines are currently being redeveloped in order to be compliant with the new and updated WCAG 2.0 specifications.

User Agent Accessibility Guidelines (UAAG)

These twelve guidelines describe how to make user agents (e.g. web browsers or media players) more accessible to users with disabilities. Each guideline also contains a set or requirements, called checklists, and these checklists must be met in order to conform to the overall document of guidelines. The priority levels of the user agent accessibility guidelines (UAAG) are identical to those of WCAG 1.0 which are defined above (UAAG 1.0, 2002).

UAAG is also currently undergoing redevelopment, like ATAG 1.0, to be compatible with WCAG 2.0 and compliant with new web browsers on the market. These guidelines are anticipated to be reworked by 2010.

Conformance Levels

W3C has specified three conformance levels which states how accessible a website or web page is. The three conformance levels are:

- *Level A:* A website or web page meets all the Level A Success Criteria.
- *Level AA:* A website or web page meets all Level A and Level AA Success Criteria.
- *Level AAA:* A website or web page meets all Level A, Level AA and Level AAA success criteria.

WCAG 2.0 has developed logos shown in Figure 2-2 for developers to include on websites as a means of specifying the conformance level of the website.

Level A: 

Level AA : 

Level AAA: 

Figure 2-2 W3C logos (reproduced from WCAG 2.0, 2008)

2.5.2 Multimodal Interaction

Multimodal interaction uses a combination of different input and output modalities in order to make systems more accessible for users with special needs. Users are presented with a choice for inputting information via visual means (i.e. text, graphics) or vocal means, while the system can output information through interface displays, recorded speech or audio.

Traditionally, the major and most common input source is graphical or sight. However, more devices are now adopting other channels such as speech and haptic (touch) channels. A haptic interface enables communication, between the user and interface, by guiding the user's touch via different sensations such as vibration and motion.

As suggested by Dix *et al*. (2004) a user's everyday interaction with his environment is composed of the utilization of the five senses: touch, taste, smell, sight, and sound. It should be expected that system interaction could also consist of more than one sensory channel. A variety of tactile hardware tools which adopt different channels for data

input are available such as specially designed keyboards, mouse, pens, touch screen monitors or microphones (Dix *et al.*, 2004).

The World Wide Web Consortium (W3C) has established a framework known as *The Multimodal Interaction Framework*. This framework is composed of W3C mark-up languages for building and supporting accessible programs through extensible mark-up language (XML), synchronized multimedia integration language (SMIL) and extensible hypertext mark-up language (XHTML) (W3C Multimodal Interaction Framework, 2003).

2.5.3 National Disability Authority (NDA) Guidelines

The National Disability Authority (NDA) launched a set of guidelines known as the NDA I.T. Accessibility Guidelines v1.1 for developing and maintaining web applications and software. There are three categories of guidelines designed for developers, designers and content providers. The guidelines have adapted the WCAG 1.0 (1999) specifications and have also cross referenced the WCAG 1.0 checkpoints. The NDA have rewritten and simplified the WCAG 1.0 guidelines in order to make them easier to understand and use (NDA, 2002).

2.5.4 Tools for Web Accessibility Evaluation

A variety of accessibility evaluation tools have been created for software developers. Developers can now validate their software against the guidelines during software

creation. Recently multimedia and web content tools are including accessibility features in their software. This built-in function allows developers to create high level multimedia software while also meeting the special requirements of many users. We next discuss some of the tools available for modern development.

- *IBM Rational Policy Tester Accessibility Edition:* incorporates features of the earlier Bobby technology, and it also includes one hundred and seventy accessibility checks for assessing website compliance. The technology evaluates the level of compliance of a website against the W3C WCAG 1.0 guidelines, through identification and isolation of issues and suggestion of remedies. Through use of the technology, more concise results can be identified, as opposed to manual checking which can cause some issues to be overlooked (IBM, 2008).
- *Adobe Acrobat, Flash, Dreamweaver:* Adobe has included accessibility features in recent additions of its development suite. Adobe Acrobat incorporates the use of tags. Tags are a mark-up language, similar to HTML and XML used to make documents accessible. Also, Adobe provides a list of best practices and procedures for developing accessible web designs (Adobe, 2009).

During the later phase of prototype development the accessibility guidelines, mentioned above, will be referred to and implemented during the design and creation of the prototype. Different multimodal technologies will also be explored in order to make the prototype more accessible. The web accessibility tools will also play a role during the

testing phases of the prototype, in order to verify that the prototype meets the requirements of each guideline.

2.6 Multimedia Lifecycle

2.6.1 Introduction to the Usability Engineering Lifecycle

The Usability Engineering Lifecycle was originally developed by Mayhew (1999). Due to the research context of this project, i.e. special needs, we examine this lifecycle as it promises to offer a solid framework for our user needs analysis and subsequent design and development phases. The lifecycle allows for a detailed investigation of usability task analysis. The early steps of the lifecycle include a thorough investigation of the user profile and task analysis in order to provide for a set of usability goals. Depending on the needs and type of software being created, Mayhew (1999) suggests that some steps can be skipped within the lifecycle if they seem unnecessary (see Figure 2-3). We now summarise the steps taken within this lifecycle which lead to the development of the prototype.

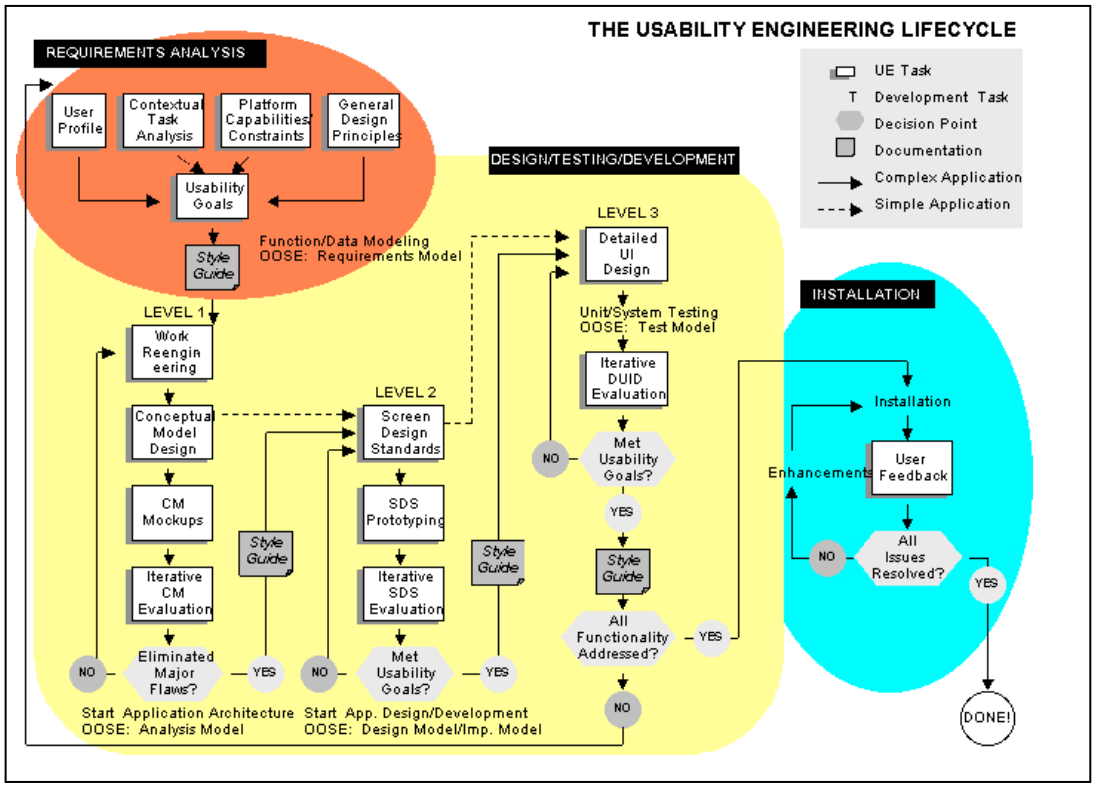


Figure 2-3 Usability Engineering Lifecycle (reproduced from Mayhew, 2008)

2.6.2 Requirements Analysis

Phase one, Requirements Analysis consists of four areas: User Profile; Contextual Task Analysis; Usability Goal Setting; and Platform Capabilities and Constraints. These four areas are documented in the project's Style Guide. During this phase HCI Design Principles are reviewed and later implemented during the design phase.

User Profile: A profile is documented which describes the main characteristics of the user. The user type is investigated in order to understand and categorise the type of end-user that will be interacting with the system.

2.6.2.1 Categories of End-User

Two major concerns involved with usability are the users' tasks and characteristics (Nielsen, 1993). It is a priority that the designer knows and understands the user and the user's needs before commencing the design phase of the system. Faulkner (2000) describes the different types of users as follows:

- *Direct Users:* Users that use the system themselves to carry out a task. In relation to this research the child with autism will be a direct user of the system.
- *Indirect Users:* Users who ask other people to use the system on their behalf in order to carry out a task. The child with autism may request the teacher or tutor to carry out a task in the system on his behalf.
- *Remote Users:* Users who do not directly use the system themselves but depend on it to complete a task. A learner with special needs may be unable to use the computer system and may depend upon the teacher to use the software on his behalf. This also gives the learner a chance to observe the lesson.

Support Users: Users who are part of the administration and technical teams who support the users of the system while they are completing a task (Faulkner, 2000).

Not only is it important to distinguish the correct category the end user belongs to, it is necessary to understand the user's individual traits, characteristics and expertise. Faulkner (2000) provides an explanation of the different expertise a user may possess:

- *The Novice User:* The novice user may have little experience of a computer or may only be a first time user. Novices will need continuous feedback from the

system to update them on their progress. They will require easy-to-understand navigation guides and menus to guide them through the system.

- *The Intermediate User:* The intermediate user may use the system for short periods or infrequent periods of time. He may possess a broad overview of the system, and can exhibit both novice and expert characteristics. The user requires good detailed online support manuals.
- *The Expert User:* The expert user has confidence using the system and has a clear understanding of how to interact with the system. Expert users need to be provided with shortcuts in order to accelerate through tasks faster.

Interviews, observations and questionnaires are appropriate measures which should be used in assessing the respective category which the end-user belongs to.

2.6.2.2 Contextual Task Analysis:

Task analysis is a process of understanding how the user interacts with the system. The overall aim of task analysis is to design a system which helps the user perform his day-to-day tasks and achieve his goals more efficiently. The users' needs and how they overcome problems which may occur during task completion must also be taken into account. Observing users in their work environment is an efficient method to collect data for task analysis. Nielsen (1993) states that an important feature of task analysis is to identify the current weaknesses that are found in the system, especially where users encounter extreme problems, and spend excessive time or fail to complete their goals. These problems present areas that should be improved in the new system.

Usability Goal Setting*:* Usability Goals are created from requirements gathered from User-Profiling and Contextual Task Analysis. These goals are later used for iterative usability evaluation.

Platform Capabilities and Constraints*:* The technology platform is considered e.g. Microsoft Windows and Apple Macintosh. The different HCI Guidelines can be considered for interface design depending on the chosen platform.

2.6.3 Design, Testing and Development

The relevant stages of Phase Two, Design, Testing and Development are summarised in the following section:

- *Work Reengineering:* Reengineering focuses on re-designing the current user's work and task methods in order to allow the user to complete his goal more efficiently. The main purpose of reengineering is to create a new method to complete tasks which is easy-to-learn, requires minimum amount of training and causes little disruption to the day-to-day running of the business. This step uses the outputs from the User-Profile, Contextual Task Analysis and Usability Goal Setting Phases. Information gathered during this phase is incorporated in the next stage, Conceptual Model Design.

  Even though the social instructional prototype is a first-time development i.e. there is not a model already in existence to be reengineered, it is important to do

an in-depth user analysis. This information should be documented appropriately so further development of the prototype could occur later down the line.

The subsequent stages of Mayhew's (1999) Lifecycle have been adapted and modified to suit the needs of this research project. An in-depth account of these stages will be discussed in *Chapter 3: Investigating the Learner Profile* and *Chapter 4: Accessibility and Usability in Lesson Development*. We will now proceed to summarise these stages:

- *Conceptual Model Design:* Major design issues are raised at this stage and decisions are made specifying the design approach. A set of high level interaction rules are established and modelled into an interface design framework (Mayhew, 1999).
- *Conceptual Model Mock-Ups:* A series of paper and pen based mock-ups are created. This stage provides a means to evaluate the design rules developed in the previous step (Mayhew, 1999).
- *Iterative Conceptual Model Evaluation:* During this stage tutors are recruited in order to perform testing on the mock-ups previously developed. Where possible testing should occur in the user's own work environment as opposed to a testing laboratory (Mayhew, 1999). From the perspective of this research these early evaluations have been completed in a local ABA school.
- *Screen Design Standards:* This stage consists of defining a set of standards to form a basis for detailed user interface design. They can also be customized in order to meet the requirements specified during information gathering in the requirements analysis phase.

- *Screen Design Standards and Prototyping:* This stage provides a means of assessing if user requirements are being addressed (Mayhew, 1999). The paper-based mock-ups created earlier are transformed into a computer-based interface design.
- *Iterative Screen Design Standards Evaluation:* Tutors are encouraged to test the prototype in order to gain feedback on usability of the model, preferably in their classroom. All error data should be documented for redesigning of the interface (Mayhew, 1999).

2.6.3.1 Style Guides

Style Guides are a set of rules which are defined in order to provide consistency throughout the interface. Microsoft provides a detailed set of guidelines in order to construct toolbars, error messages, side navigation bars and icons for its Windows platforms (Microsoft Corporation, 2008).

- *Detailed User Interface Design (DUID):* A detailed user interface design is developed based on the conceptual design model and screen design standards.

  The navigation menus, buttons and pop-up feedback boxes are all developed at this point (Mayhew, 1999).
- *Iterative Detailed User Interface Design Evaluation:* The final fully developed prototype is evaluated and tested against the early tutor requests.

2.6.4 Installation

The final phase, *Installation*, includes a single stage referred to as *User Feedback*. This stage is discussed in the subsequent section.

User Feedback: User feedback provides information on the usability, i.e. learnability, and ease-of-use (Preece *et al.,* 2007), of the system after it has been installed. The feedback obtained can be used to provide an account of what maintenance or enhancements need to be applied to the system. The feedback can also be analysed and incorporated into further releases of the system or in the development of parallel products which will be used by similar users. Feedback can be gathered by using the following methods: questionnaires, focus groups, interviews and usage studies. Each of these techniques and how they will be used within this study are documented next in our section on research methodology.

Mayhew's (1999) usability lifecycle provides the 'user-centred' design approach which allows for a close working relationship with tutors during each development stage. The lifecycle also provides for the merging of HCI guidelines, accessibility guidelines and ASD user research during requirements analysis phase.

2.7 Research Methodology and Ethics

Research methodologies play an important role throughout this project. Careful procedures are implemented during fieldwork, while working with young learners with special needs.

2.7.1 Applying Methodology to Research

The teaching and learning process is a complex and in-depth system. From the literature, it has been suggested that sometimes misleading or incomplete data is achieved through the use of a single method in the school environment (Cohen and Manion, 1994). It is intended that by using the triangulation approach more accurate findings can be achieved.

2.7.2 Triangulation

Triangulation uses a combination of different sources or methods in order to overcome deficiencies and bias that may occur through use of a single method and to establish accuracy in information and findings in order to answer the research question.

Denzin (1970) describes four different types of triangulation:

- *Data Triangulation:* The researcher uses a variety of different data sources. Researchers search for as many different data sources as possible which relate to

the subject being researched i.e. interviewing and observing different role groups.

- *Investigator Triangulation:* Multiple observers are employed as opposed to a single observer. The use of multiple observers removes any bias that may come from a single observer. This ensures more reliability in observation.
- *Theoretical Triangulation:* The use of multiple theories or hypotheses to guide the study.
- *Methodological Triangulation:* A combination of different methods to measure the same unit i.e. qualitative and quantitative measurements.

For the purpose of this research methodological triangulation appears appropriate as our research approach will include:

- Fieldwork
- Observation
- Questionnaires
- Interviews.

Through a combination of these investigative approaches, it is hoped to validate results obtained from these different elements and to enhance confidence in findings.

2.7.3 Fieldwork

The opportunity to gain access to people, places and events through fieldwork is an important and essential element of completing successful research (Denscombe, 1998). Spending time in the field observing learners interacting with software and communicating with tutors is a crucial aspect, which serves as a guide for the design and development of computer software.

2.7.4 Observation

Visitations to schools provide an ideal opportunity to observe children interacting with software and computers. It is also important to observe the amount of dependence the learner has on his tutor and the interactions between the tutor, the learner and the software. Observational methods provide a firsthand approach at viewing users interacting with software. This method can also highlight difficulties or preferences that users display towards the software.

Druin *et al*. (1999) summarise a list of techniques that have been effective in their studies and observations with children. During the current research, the researcher considered these steps while conducting observations.

- *Go to "their territory":* As suggested by Druin *et al*. (1999) children will be more comfortable and at ease in their own environment. Especially when it comes to considering the needs of learners with autism this is most important.

These children like to follow a strict routine, and any changes in their environment can lead to confusion.

- *Give children time:* It is important to give children time and space to explore, play and feel at ease with software and become accustomed to the situation, before asking questions (Hanna *et al.*, 1997; Druin *et al.*, 1999).
- *Wear informal clothing:* Wear casual clothing, similar to that of the teacher and parents, which is familiar to the child.
- *Use small notepads:* As the researcher will take notes during observations, Druin *et al*. (1999) suggest the use of a small discrete notepad, as the use of large notepads can distract the child and may make him feel uncomfortable.

2.7.5 Questionnaires

Questionnaires can serve as data gathering tools to gain feedback on different aspects of software during usability testing. The questionnaire will serve as part of an acceptance test for the prototype. Should the prototype fail to meet all requirements, the system will be reworked until success is demonstrated (Shneiderman, 1998). It is hoped that data gathered from this method will provide information on the key users' characteristics, behaviours and attitudes towards the software (Kendall and Kendall, 1999). The main objective of the questionnaire is to measure the user's satisfaction towards the software.

Questionnaires usually contain lists of standardized questions both closed and open-ended. Interface design questionnaires regularly investigate key components of the software such as usability, interface design and learnativity (Preece, *et al*., 2007). By

designing the questions in this format the goals of the research should be achieved (Robson, 2002). The data obtained should provide a clear response in relation to the accessibility of the software for the learner with special needs. It should also provide an indication if further modifications need to be applied to the prototype.

2.7.6 Interviews

Interviews are a common technique used to collect information and data. For the purpose of this research, interviews will be informal in structure. The aim of this method is to influence the interviewee to become a collaborator (Lomax *et al*., 1996). It is important to involve the tutors and teachers and to obtain their opinions and insight into the software usability and effectiveness of educational software on learning. It is essential to gather information and understand the user requirements during the requirements phase in order to formulate an appropriate design method for the prototype.

The combination of questionnaires, observations and interviews, used to create a triangulation framework, is an ideal information gathering tool to meet the requirements of learners with special needs. The researcher can gain an accurate response through a variety of different methods, while working closely with the end-user.

2.7.7 Ethics

Throughout this research, investigations and documenting of data is conducted following strict ethical guidelines. Data provided from the participants is stored securely using encryption and passwords. Information relating to the participants remains anonymous throughout this research. As the role of the researcher also entails the responsibilities of a data controller, the data protection rules are adhered to during the project (Data Protection Commissioner, 2008). Details of information handling and fieldwork visitations are agreed upon by the researcher and participants. As the nature of this research involves the researcher collaborating with a vulnerable group in the community i.e. children with autism, clearance for the research was obtained from the Waterford Institute of Technology Ethics Advisory Committee.

2.8 Concluding Remarks

Upon review of the literature, particularly taking into account initiatives by Baron-Cohen *et al.* (2007) and their Transporters, Bondy and Frost (2001) and Moore *et al.* (2005), it can be considered that animations and technologies have a predominant role to play in advancing the social skills development of young learners with autism.

Earlier studies have shown that computer and web-based technologies have the potential to provide a safe learning environment, for special needs learners. By taking into account recommended HCI guidelines (Jones and Okey, 1995; Norman, 1998; Shneiderman, 1998) and web accessibility recommendations (WAI, 2006), an easy-to-

use, unambiguous elearning program could be created in response to our own proposed fieldwork and user analysis.

Our subsequent research steps will aim to apply the guidelines documented in this chapter to the design, development and evaluation of an accessible online multimedia social skills lesson.

3. Chapter Three: Investigating the Learner Profile

3.1 Introduction to the Learner Profile

The main aim of this research was to develop a multimedia software program to aid the social skills development of young learners with autism. Information was gathered in relation to autism, interface design, HCI guidelines and computer usage among young learners. This data was implemented into the design methods documented within this chapter. The body of work contained in this chapter discusses observations, interviews and early evaluations completed within the field. The chapter then details a step-by-step commentary of the early design phases of the social skills prototype.

3.2 Requirements Analysis

The Usability Engineering Lifecycle is the main feature throughout the design phases of the prototype. Mayhew (1999) recommends adapting the lifecycle to suit different types of technology development. Throughout this chapter, diagrams will be used to illustrate how Mayhew's lifecycle has been customized to suit this research project.

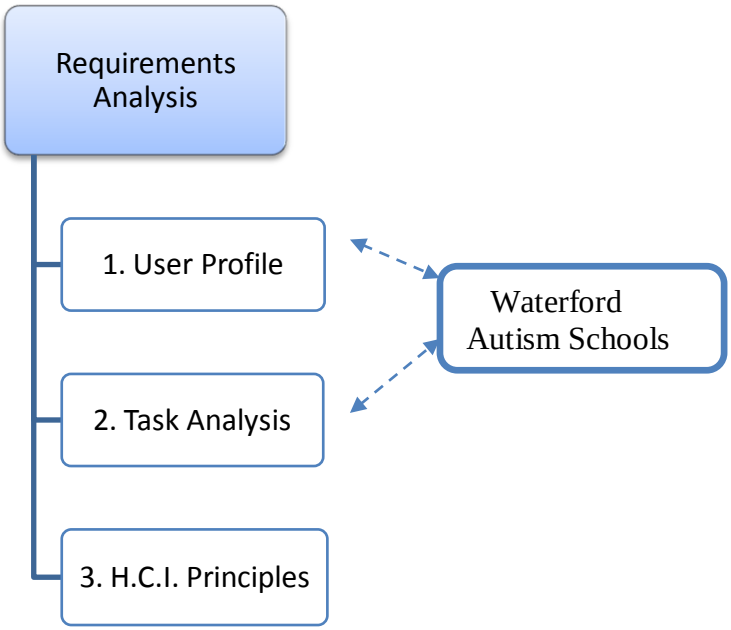


Figure 3-1 Requirements Analysis diagram

Requirements Analysis involves the gathering of information from different sources prior to the commencement of design. Requirements Analysis provides the researcher with an understanding of the user and how he conducts his daily tasks. The researcher used the triangulation approach during data collection. Information is gathered from three main sources in this research: user profile, task analysis, and HCI principles. Due to the sensitive nature of this research area, extra care and special methods are used during user profiling. These are documented further in this chapter. The fieldwork, completed in local autism schools in Waterford, gathers data for both the user profile and task analysis steps and is given in Figure 3-1.

Fieldwork in Local Special Needs School (School A)

Much of our early investigations were conducted in a local special needs and applied behaviour analysis (ABA) school located close to Waterford City. The children attending the school range from preschool age to eighteen years of age. The focus of this research is based with a class of five mixed gender learners, with autism and special needs, aged from five to nine years of age. The class is taught by a teacher who runs the day-to-day curriculum, along with the assistance of a special needs tutor.

During this phase of development meetings with tutors in School A, parents of young children with autism and tutors in another local special needs school (which shall now become known as School B) were arranged by the researcher. These meetings were mainly composed of informal interviews, in order to gain input on different aspects of the prototype. A summary of observations and evaluations is documented in Table 3-1.

Table 3-1 Record of fieldwork throughout storyboarding and mock-up phases

Visit ID	Date	Venue	Objective
1	1/2/2008	School A	▪ Initial observations of students and classroom environment. ▪ Discussion of software available within the class and how children interact with computer tasks.
2	11/04/2008	School A	▪ Paper-based storyboard evaluation.
3	20/5/2008	Interview with parent of child with autism	▪ Initial interface design evaluation.
4	6/6/2008	School A	▪ Initial interface design evaluation.
5	10/6/2008	School B	▪ Initial interface design evaluation.

3.2.1 User Profile

The first step taken during Requirements Analysis was to begin to construct a model of the user profile. The next sections describe the procedures taken in order to create this user model.

3.2.1.1 Communication Method within the Classroom Environment

Young children in the four to nine year age range are the primary users of this system. These users are young primary school children with autism who attend a special needs school in Waterford (School A). As stated in *Chapter 2: Literature Review*, these young learners have difficulties in understanding social skills and may have no 'Theory of Mind' (Baron-Cohen *et al.*, 1985). Many of the children in the school have limited verbal skills and do not possess a wide range of vocabulary. To overcome this difficulty the school has implemented the PECS system into some of the classrooms (Bondy and Frost, 2001). Within the classroom each object, from a chair to a shelf, is labelled with its appropriate name along with a velcro patch to allow the child to attach the PECS card.

3.2.1.2 Teaching Structure in the Classroom of School A

The children spend an allocated time each week within the class schedule using the computer. The teacher follows strict ABA guidelines within her classroom structure and in each lesson. These ABA guidelines are implemented at timetable level down to individual level. The children in the class prefer to follow a strict routine. Their days are planned on a weekly basis and a review of the forthcoming day's activities is discussed every morning. The children have a large personalized chart affixed to the wall over their desk so they are aware of what is coming next.

3.2.1.3 Hardware

The classroom computer is equipped with a touch screen monitor. The children show a preference for this method of input as they are only required to touch the screen. There is also a switch available as an alternative method of input. Some children find this method easier to use as opposed to a mouse, as it requires less effort from motor skills.

3.2.1.4 Types of End-User

All the children in the school are novice users of the system. They possess a small amount of knowledge about computer systems. As they currently only use the computer at specific allocated times of the week, they are not familiar with the overall structure of the computer system or software. The children will require continuous feedback and easy-to-use navigation menus.

Currently the children have a limited amount of software available to them. The software includes basic vocabulary training skills and colour learning skills. The children can input the disks independently and the software automatically starts. However, the teacher's assistance is required to start the computer and to shut the computer down.

- *Direct Users:* The children will be direct users of the software. They will use the software to be developed in this study, to read and learn about social skills. Sometimes, children in the class have a tendency to sit away from the group and observe a new game or task before participating in it themselves.

- *Indirect Users:* Some of the children may begin as indirect users; they will sit on a chair and watch their class colleague use the software a number of times before they explore the software themselves.
- *Expert Users:* The teacher and tutor of the class will be expert users of the software, as training in the software will be provided to them before the software is made available to every pupil. The teacher and tutor will then serve as a support user to the learner, until the learner is fully competent with using the software independently.

3.2.1.5 User Roles

In order to build a complete profile of the different types of user for the system, it is important to understand the variety of roles that a person can have. Druin (2002) has developed four roles that are specific to a child during software development (see Figure **3-2**). The child can have any number of these roles throughout the different design phases of the software lifecycle. From the perspective of this research, it must be remembered that the children involved are of a young age group (four to eight years of age) with autism. Hence, this model will be adapted to suit the needs of the child learner with special needs.

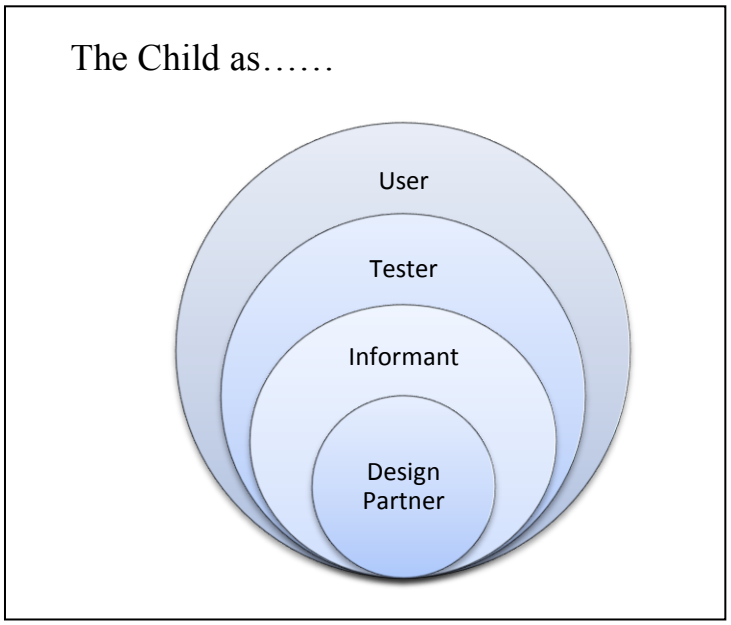


Figure 3-2 The four roles of children (redrawn from Druin, 2002)

The children involved with the development of this project will fall under two categories i.e. user and tester. Within the user role, the young learner will become a user of the prototype. During this phase, it is hoped that the child will be recorded and observed using the prototype. This will supply the researcher with information about the usability of the prototype (Jarrett *et al.*, 2005). The researcher can observe any problems or preferences that the child may have using the software. The impact that the technology has on the learner after use is very important. In order for the prototype to be successful the learner should be able to adapt the skills learnt from the software to his everyday routine.

Children could begin the tester role after the original prototype has been developed. Children's reactions and feedback can highlight problem areas of the software that may currently exist. Input from the child during the testing phase can vastly improve the

design of technology, as the researcher receives direct comments from a child's point-of-view.

The participation of the teacher is also considered throughout the user and tester roles. However it should be remembered that the child has learning difficulties so the teacher may need to provide some assistance in order to help the child. It must be noted, that due to the nature of this project the tutor will be required to co-operate as the informant and design partner roles as opposed to the child.

3.2.2 Task Analysis

Task Analysis is the process of understanding how the learner currently uses software and interacts with the computer. The findings from task analysis will help the developer in creating a usable software package that will allow the child to complete lessons in relation to social skills development. Prior to the commencement of development, the researcher spent time in the school environment, observing the day-to-day routine of the child. The researcher also held informal interviews with the teacher. Details of the task analysis interview questions can be found in *Appendix B: Interviews*. The teacher demonstrated the different software and discussed the current problems and benefits of the technology. The teacher also discussed with the researcher design issues and topics to be covered in the lesson plan.

It is important for the researcher to gain an understanding of how the children currently interact with the technology available in the school. A number of children in the classroom were observed using the classroom vocabulary software.

As suggested by Hanna *et al*. (1997), instead of requesting young children to complete a series of direct tasks it is more appropriate to allow the children to explore the software at their own pace. As they still are at a very early school level they will find drill type tasks difficult to follow and tiresome.

Children at this young level will also have different behavioural characteristics: smiling, giggling, yawning, frowning, and sighing. Each individual behaviour can be used as an indicator as to what the child is thinking about the software (Hanna *et al.*, 1997; Hanna *et al.*, 1999).

Throughout each school visit, documented as visit ID 1, 2, 4 and 5 in Table 3-1, the researcher was careful to adhere to each of Druin's (1999) observational techniques. The researcher visited the children in their designated classroom and sat with the children at their own level when observing their classroom activities. The researcher took all notes discretely in a small notebook and asked permission from tutors before displaying the laptop. Further discussions with tutors and demonstration evaluation sessions took place in the tutor's office.

3.2.3 HCI Principles

HCI principles are implemented throughout the development phases of the prototype. A detailed discussion of HCI principles can be found in *Chapter 2: Literature Review*. During these early investigations recommendations from Nielsen (1993), Jones and Okey (1995), Shneiderman (1998) and Norman (1998) were evaluated. It was

concluded that four guidelines should be prioritized when designing for learners with autism, and these are listed as:

- Simplify the structure of tasks
- Design for error
- Strive for consistency
- Reduce short-term memory load.

Throughout the next sections the design and development of the prototype is discussed. The HCI guidelines, particularly the four listed above, are an important element during these subsequent phases.

3.3 The Design Approach

Mayhew's (1999) design structure has been modified to capture the methods used to create the final prototype. The design phase is divided into three levels which demonstrate the progression of the prototype. These levels are listed as follows:

- Conceptual Model Design
- Screen Design Standards and Prototyping
- Detailed User Interface Design.

3.3.1 First Design Phase: Conceptual Model Design

The initial design phase lays the foundations for beginning the design process. Conceptual Model Design and mock-ups are drawn up, shown in Figure 3-3, based on findings from initial requirements analysis. The final paper-based mock-ups are evaluated with the teacher or user to discuss if they meet the criteria previously specified. As these are only paper and pen sketches they provide a quick and cheap method for creating designs while talking to users.

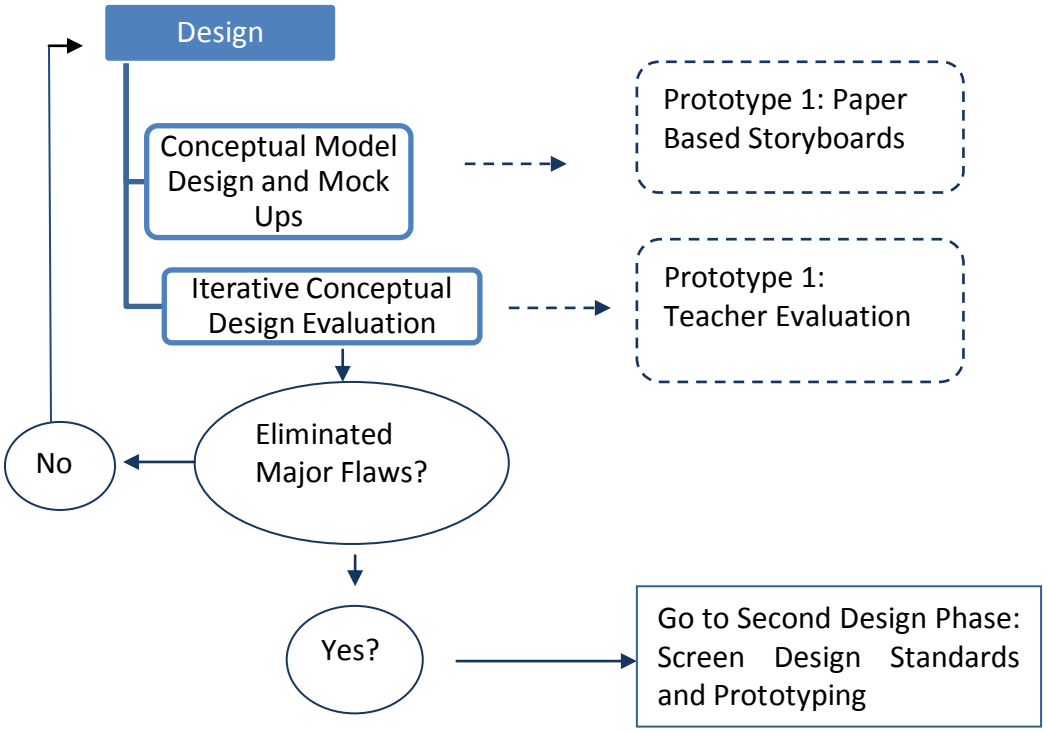


Figure 3-3 Conceptual Model Design (adapted from Mayhew, 1999)

3.3.1.1 Technologies

Throughout the design and development phases, the different technologies used by the researcher are reviewed and discussed. We provide an evaluation of each technology's success and usefulness, at completing its task. The researcher used the following development tools:

- *Photoshop CS:* Photoshop CS was the main tool used for drawing the paper-based storyboards shown in *Appendix A: Storyboard Screenshots*. This package was used to edit and develop the image used as the main background of the interface. Also created within Photoshop are the three images used as rollover buttons for the main navigation on the interface.
- *Flash 8:* Flash 8 is a multimedia web-based movie software tool. This is the main software used in the development of the multimedia story *Washing My Hands*. The software allows for easy implementation of audio which was useful in the creation of narrations for the story. Each spoken word is highlighted so the child can follow along with each step. This allows the young learner with autism to listen to the story at his own pace, and replay the voice instruction again in his own time. It could also be said that the speech-based approach is a more natural way to learn the lesson content, as language is learned primarily through speech (Feng and Sears, 2007).
- *Dreamweaver 8:* Dreamweaver 8 is a powerful website editor tool. The researcher used this tool for creating and editing each web page within the prototype. The Flash movies and graphics were imported onto the web page via this tool so they could be displayed on each webpage. Hyper Text Markup

Language (HTML) is a text file consisting of tags (code) which tells a web browser how to display text and images within a webpage. HTML pages are created within the web editor tool Dreamweaver 8, which is used to create and display the main text within the prototype.

- *Cascading Style Sheets (CSS):* Cascading Style Sheets are implemented within the design in order to control how web pages are formatted. The Cascading Style Sheets serve as a template so that size and colour of all fonts, links and graphics are uniform across each web page. This can respond to the need for 'sameness' or 'strict routine' that many of the young learners require. The predictability found in the Cascading Style Sheets can provide for a concrete working space which can be replicated across all pages of the software. If each page layout is in the same format the learner can anticipate the next page of the prototype (Peeters, 2000).

3.3.1.2 Software Benchmarking

A number of different online children's websites and software were reviewed prior to design (Table 3-2). This review provided the developer with ideas in relation to navigation, technology and use of colour.

Table 3-2 Software and websites reviewed during design

Software or Website	Description
Teachtown, Learning with Timo	Autism software currently being developed by researchers in the US.
Touch Funfair, Lamara Happy Duck	Touch screen software currently in school A.
Reader Rabbit, My First Encyclopaedia, Jump Ahead Reading	Software recommended by parents of children with autism.
Sesame Street, Disney Playhouse, Nickelodeon (nick.com), Cbeebies (BBC young learners activity website)	Popular television programmes and children's film websites.
The Transporters	Social skills and facial recognition television programme developed by researchers in Cambridge University.

Some of the ideas which evolved from this benchmarking strategy provided a fresh approach to the early design of the prototype. A summary of the main issues which arose are listed next:

- The use of voice and sound can provide an important tool for navigation and use of the software.
- Simple primary colours and clutter-free work space can be more effective.
- Simple navigation such as buttons can be easier to navigate. On some websites the menu systems disguised as different animations are too abstract and the drop-down approach can be difficult to navigate.

The developer created paper-based sketches to use as a guide or framework of the overall design of a screen or a lesson. Photoshop CS graphics software was used to create a computer generated image of the sketches. Online graphic and font repository and sharing archives were used to experiment with different graphics and fonts in the prototype. The researcher designed four storyboards to present to tutors on which to gain advice. Figure 3-4 represents one of the storyboards evaluated by the teacher in School A. All evaluated storyboards can be found in *Appendix A: Storyboard Screenshots*.

3.3.1.3 Iterative Conceptual Design Evaluation

The researcher conducted a semi-structured interview with the teacher to obtain feedback on the paper-based prototypes. Preceding the interview, the researcher decided to focus the topics for discussion around navigation, colour, story themes, universal symbols and buttons. A description of the questions asked are detailed in the storyboard evaluation found in *Appendix B: Interviews*. The overall conclusion confirmed that the teacher was in agreement with storyboard 2, (see Figure 3-4) as the main screen interface to develop.

- *Navigation:* The main navigation consists of three simple buttons: 'home', 'stories' and 'quiz'. There should be no drop-down menus incorporated in the design as children at this level cannot cope with menu navigation and overloading of options.

- *Fonts:* The teacher agreed with the use of fonts Comic Sans or Century Gothic, as they are clearer for the child to read.
- *Universal Buttons:* Each individual child has his or her own level of ability so the teacher agreed that it would be a good idea to incorporate universal buttons such as 'play' and 'pause'. As we know from the literature, pictures are often used instead of words when instructing a learner with autism (Grandin, 1995; Howlin, 1998; Bondy and Frost, 2001). These symbols could be additional knowledge that would be beneficial to the child to learn and could help with the transfer of skills.

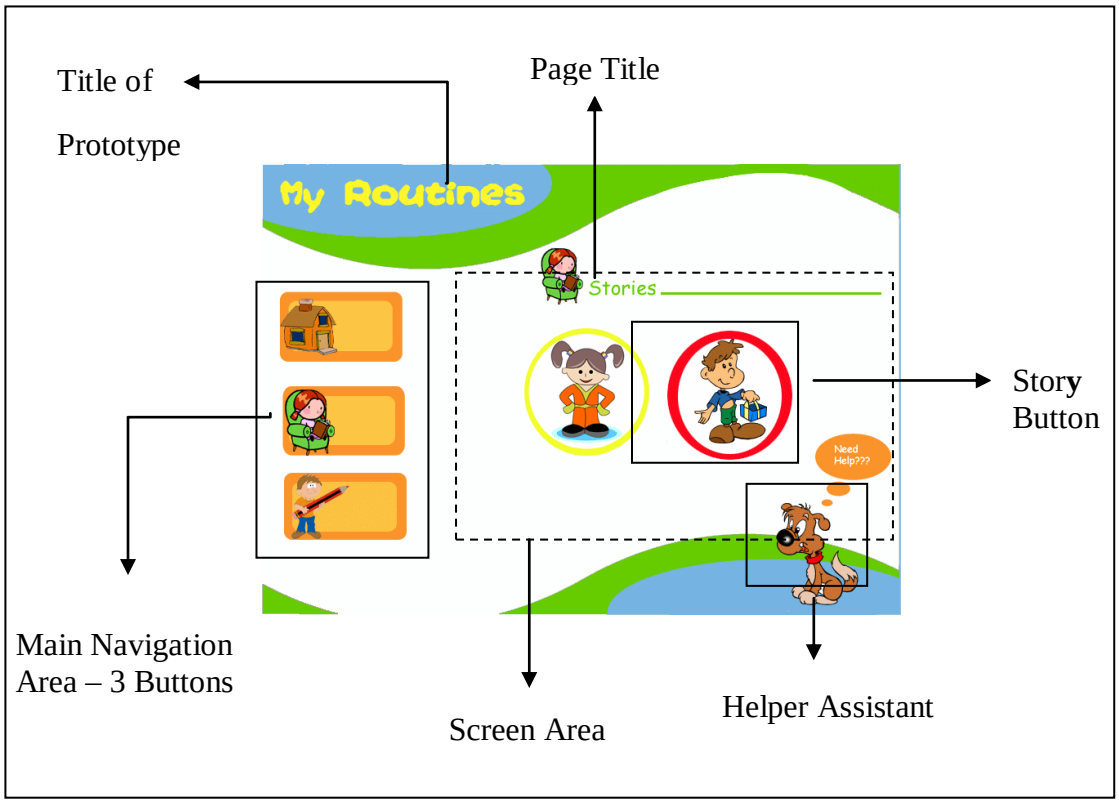


Figure 3-4 Sample screenshot of paper-based storyboard

- *Story Themes:* The teacher recommended social story topics that children already were accustomed to in their everyday lifestyles. The researcher decided to focus on topics associated with personal hygiene for example washing hands.

Based on the positive teacher evaluation there were no errors to be addressed in the storyboards. The next step in the design process is to create a computer-based version of the prototype.

3.3.2 Second Design Phase: Screen Design Standards and Prototyping

The second step of the design phase consists of the creation of a computer-based version of the paper-based prototype (see Figure 3-5). During the initial phases of design a sketched storyboard was evaluated by tutors. After additional discussions with tutors, a series of further onscreen recommendations were highlighted. Next we describe the second design phase and a detailed synopsis of the interface design is discussed below.

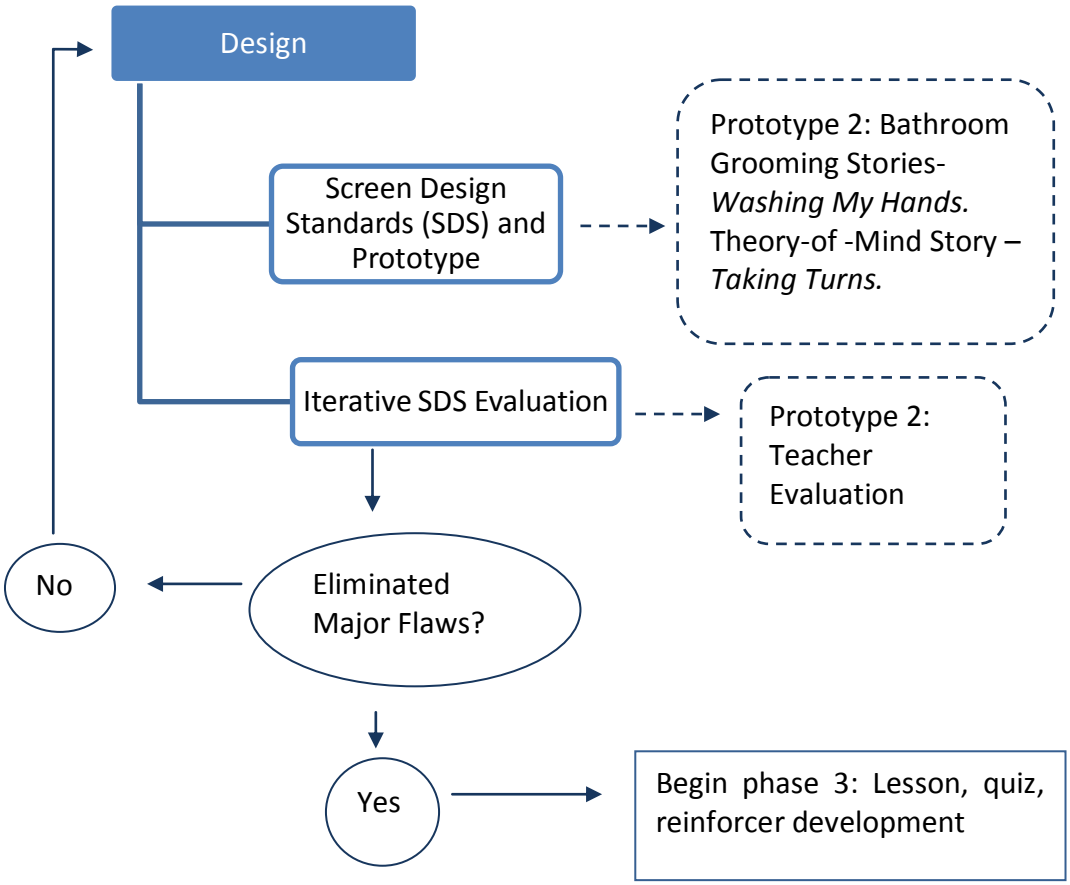


Figure 3-5 Screen design and early prototyping (adapted from Mayhew, 1999)

3.3.2.1 Designing the Interface and Screen Components

The second phase of prototype development incorporates three main components: the design of the interface; the design of the instructional story, *Washing My Hands*; and the theory-of-mind story *Taking Turns*.

Before any design activity began the developer created a number of folders for images, pages and Flash animations as shown in Figure 3-6. Organisation of all relevant

information is important from the beginning as it makes development and design easier further along the way.

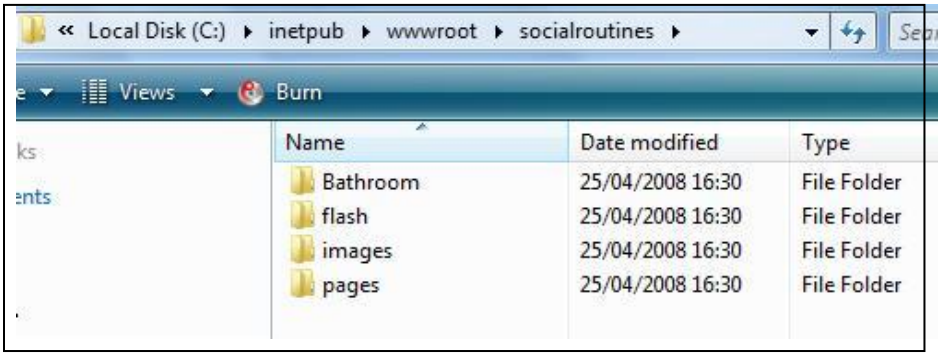


Figure 3-6 Organisation of folders for website

The Interface:

The design of the interface incorporated two main tools, i.e. Photoshop CS and Dreamweaver 8. Initially the image of the background was modified in Photoshop CS and integrated into Dreamweaver. The researcher developed the main pages, text areas and lessons within the recommended safe area of width 760 width * 410 height. To comply with cognitive load theory, all information would be displayed to the learner on the screen without causing the extra task to the learner of scrolling the page to view additional information. (Shneiderman, 1998; Nielsen, 2002). The learner, parent or teacher may also wish to print lessons from the screen, so the safe area provides for an appropriate print area and all the lessons will replicate from screen to paper. See Figure 3-7 for diagrammatical representation of the screen's dimension, shown in pixels.

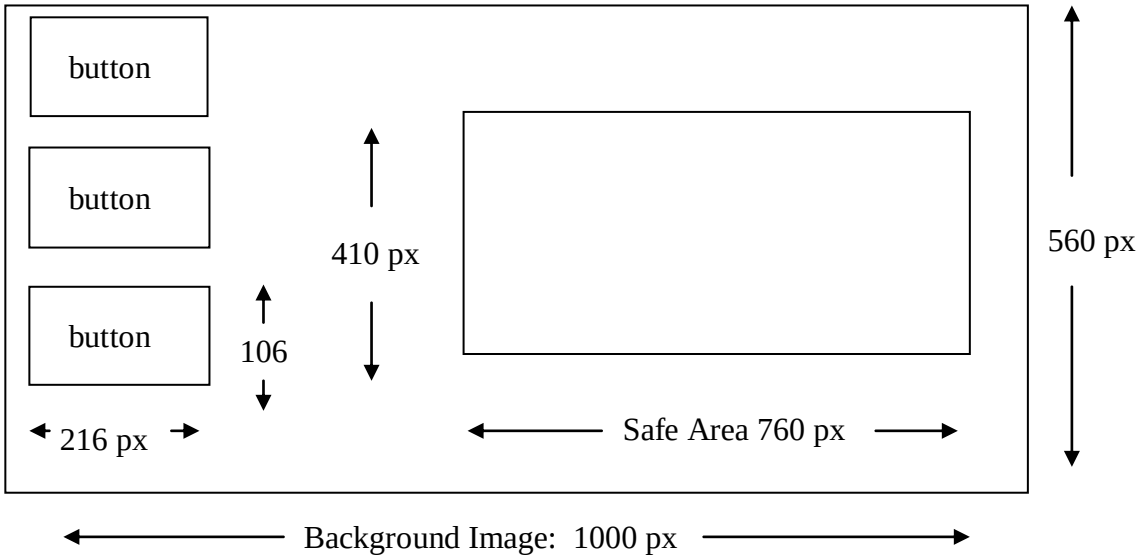


Figure 3-7 Diagram of Screen Dimensions

The main navigation consists of three buttons, i.e., 'home', 'stories' and 'quiz'. Three simple buttons as opposed to a drop down or cascading menu is more appropriate for a child with possible motor disabilities. Donker and Reitsma (2007) recommend a button of 27px width * 27px height to get a more accurate and quicker reaction time from a normally developed user. Furthermore, studies in reaction time and accurate input measures via touch screens (again for the normally developed user) suggest a button size of 40px *40px or 50px * 50px (Sun et *al.*, 2007). For the current study, the designer has created each button to a measure of 216px width * 106px height, to meet the specifications of both mouse input and touch screen input (as in Figure 3-7) along with a subtle change of colour when rolled over, to suit the special needs user.

Design of Social Scenario Animation: Washing My Hands

The prototype *Washing My Hands* is a social procedural story designed to teach the learner how to wash his hands in six steps. The story is adapted from those written by

Gray (Gray and White, 2002). Each procedure has been condensed and text is limited to a maximum of three sentences per screen. The developer has highlighted the spoken text in time with the audio so the child can follow the words along with voice. As per the teacher's advice the developer has limited the number of controls on the screen to two buttons, i.e., 'play' and 'stop'. The child can stop the movie at a specific screen if s/he wishes to spend more time reading or learning a step. The developer created the text using Comic Sans which was agreed previously with the teacher. The teacher noted that her students can read and follow text more clearly in the Comic Sans style font. The developer also chose pastel shades such as blues and purples so as to prevent a glare from the movie. In Figure 3-8 we show a diagrammatical representation of the *Washing My Hands* sample page.

Instructional aspects of the *Washing My Hands* prototype:

1. Introduce to the learner the reason for washing his hands.
2. Explain to the learner the different times when he should wash his hands.
3. Present the learner with a set of instructions that should be completed when washing his hands.

The various prototype design aspects are as follows:

1. Sans serif font, Comic Sans, for ease of reading.
2. Two buttons, 'play' and 'stop', for control of movie.
3. Pastel colours, for ease of reading.
4. Highlighted text, so the learner can follow the text along with the audio.
5. Maximum of three sentences per screen in order to prevent cognitive overload.

6. Instructional graphics displayed with a list of directions, on most screens, to aid with understanding and knowledge transfer.

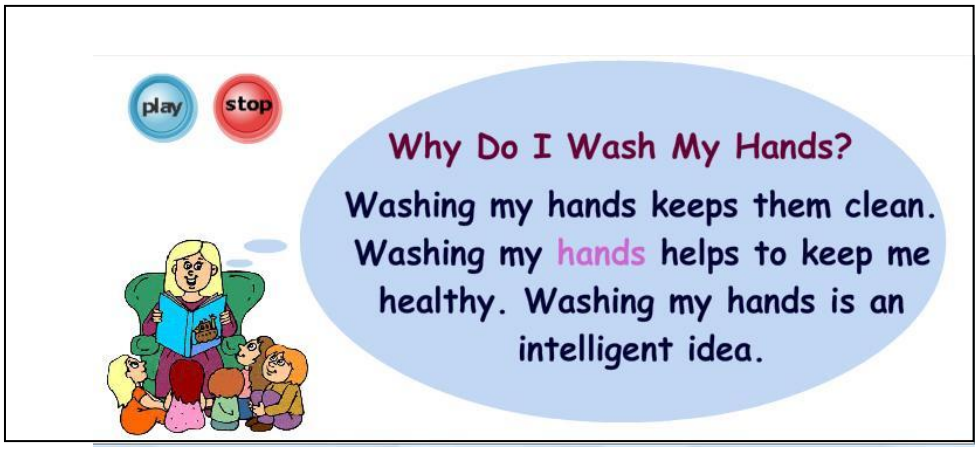


Figure 3-8 Flash interface *Washing My Hands* Movie

Design of Social Scenario Animation – Taking Turns

The second prototype is a non-procedural theory-of-mind story to teach the learner the social skills of sharing and taking turns. The developer based the story on the same format as the *Washing My Hands* prototype. The structure of the story, again, is based on the social stories of Gray (Gray and Garand, 1993; Gray and White, 2002). The same size and type of buttons, colours, font size and type are repeated. The social story describes to the user how to share and when it is his turn. Each point is supported by an image to reinforce the transfer of knowledge (see Figure 3-9).

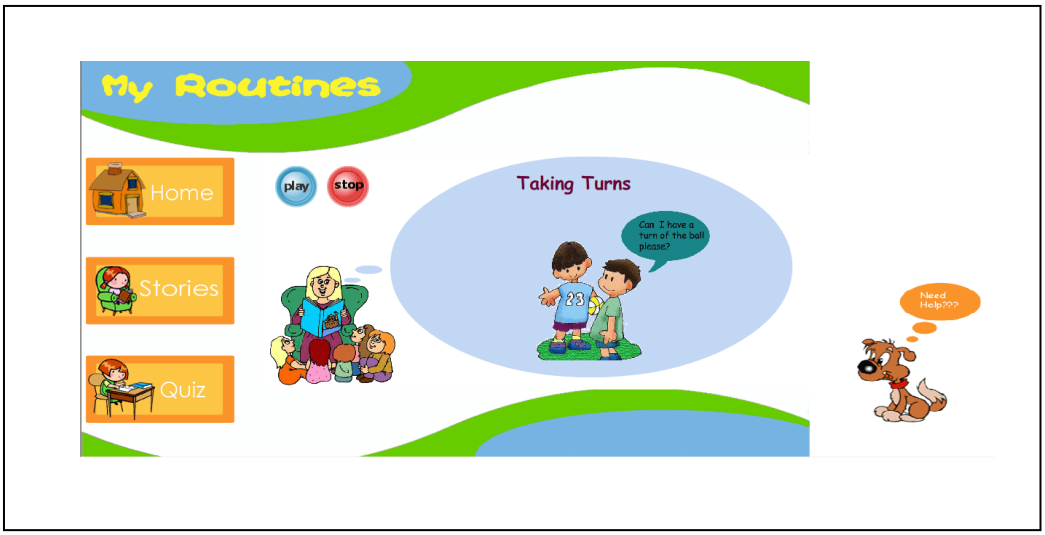


Figure 3-9 Flash interface *Taking Turns*

3.3.2.2 Tutor Evaluation of Screen Designs

The researcher conducted a semi-structured interview and demonstration of the prototype with the tutors (*Appendix B: Interviews*). The evaluation covered the following areas: story topics, interface design of the lesson prototypes, reinforcers, and music. The tutors found the usability of the lesson interface suitable for the target audience of her class. The interface was designed according to suggestions made at the previous evaluation of the paper-based prototypes. The control options of just two buttons including the text 'play' and 'stop' for each lesson was considered to be manageable by the learners. As the design of the interface remained the same as that of the paper-based prototype, i.e., choice of colour, font size and one browser window, the teacher concluded that she could not foresee any major changes to the overall design of the interface. However, the teacher did suggest some minor adjustments for the *Taking*

Turns prototype. The issues which arose from this discussion are summarized as follows:

- Too much text was displayed on each screen. The learner may become overloaded with too much information from one screen. It would be easier for the learner to follow if the text on each of these screens was separated onto new screens and reinforced with an extra graphic.
- Eight different paper-based mock-ups of reinforcers were presented to the teacher as samples that may motivate the learner. It was agreed that the reinforcers would encourage the learner to complete a lesson, as they were similar to games that the children already enjoyed playing on the computer. As the learner progressed through the lessons, the reinforcers would become less frequent so as to motivate the learner to work harder at a lesson.
- The teacher made the additional suggestion of a word and vocabulary based game to be included in the quiz section. The children could learn new words and phrases which could enhance the verbal skills while also learning new social skills.

3.3.3 Third Design Phase: Detailed User Interface Design

The Detailed User Interface Design (DUID) is the third phase of our design. This phase incorporates the overall development of the multimedia social scenario lesson. As this phase incorporates an in-depth discussion of technologies, computer-based

development, accessibility tests and evaluations, *Chapter 4: Accessibility and Usability in Lesson Development* has been dedicated to these discussions.

3.4 Concluding Remarks

Within this chapter the initial design of the prototype was discussed. Interface design aspects considered appropriate for the young learner with autism were researched during fieldwork in the schools, with reference to the literature and by examining samples of existing software. Firstly paper-based prototypes were created and evaluated with tutors. Following feedback from interviews, a paper-based storyboard was then transformed onto the screen. This screen design was also evaluated with tutors.

Following tutor feedback from the screen design evaluation, software development of the prototype was ready to begin. The next chapter (*Chapter 4: Accessibility and Usability in Lesson Development*) will document the development and design of the social scenario lesson.

4. Chapter Four: Accessibility & Usability in Lesson Development

4.1 Introduction

The next phase in development is to design an online version of the prototype. A user profile has been investigated and outlined which documents requirements of the user with special needs. Also early design storyboards and paper-based prototypes, which have been researched and evaluated with special needs tutors, form the blueprints to be developed further for an online presence. In this chapter the development of the prototype is documented based on Mayhew's (1999) usability engineering lifecycle. The Detailed User Interface Design (DUID) of lessons, the quiz and reinforcers are developed for an online audience. Finally a detailed user evaluation is undertaken to test accessibility and design features of the prototype.

4.2 Detailed User Interface Design

The third phase of Mayhew's (1999) Usability Lifecycle has been adapted in Figure 4-1 to represent the formation of the lesson, quiz and reinforcers (small groups). This current development phase follows the two design phases, mock-ups and storyboarding and screen design standards and prototyping, which have been discussed in the previous chapter, *Chapter 3: Investigating the Learner Profile*. Prior to the commencement of the development phase, a detailed requirements analysis study was undertaken in special needs schools. A user profile was created which provided a basis for the early design phase of the prototype. Paper-based storyboards were created and evaluated with tutors. The final paper-based sketch was then designed and transformed for the computer screen.

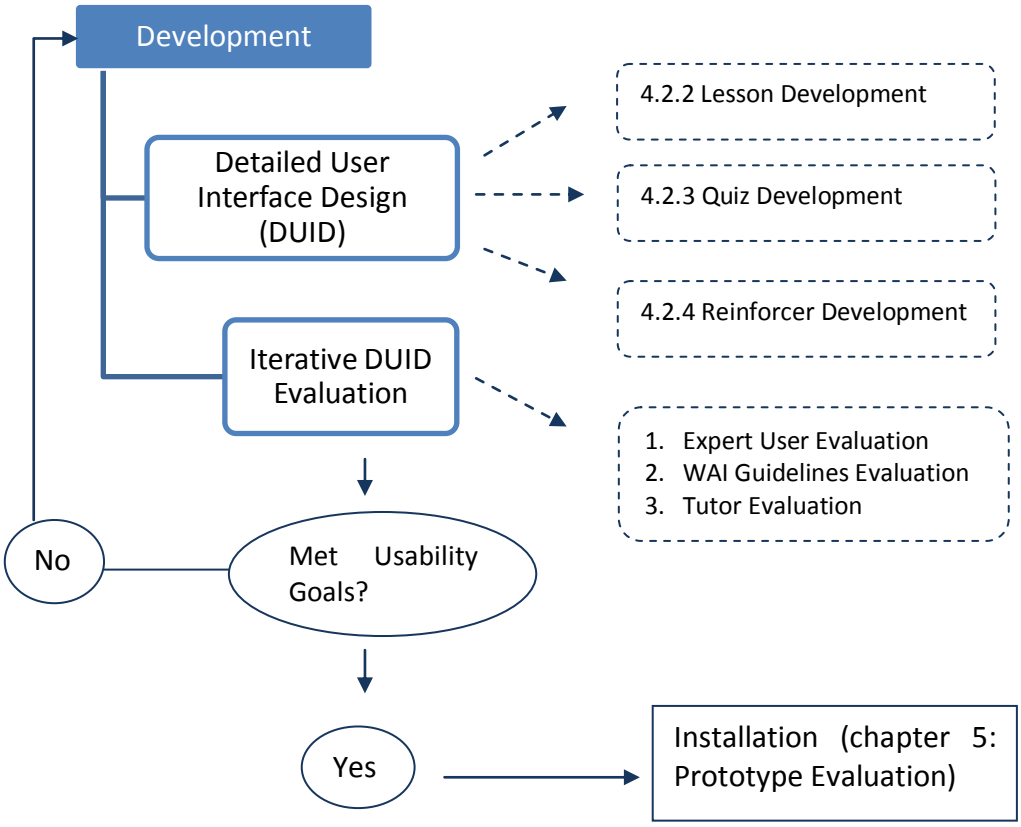


Figure 4-1 Detailed User Interface Development (adapted from Mayhew, 1999)

The Detailed User Interface Design comprises three areas of development: further advanced development of lessons, quiz development, and reinforcer development, while also adding further enhancements to the screen for online usability. Findings from task analysis during the *Conceptual Model Design Phase* are included in the design of the prototype. Throughout this chapter, design and standards during the development of the prototype are documented.

4.2.1 Technological support for usability concerns

Various technologies were used during prototype development to meet the usability and accessibility requirements of the learner with autism. The different technologies included software tools for rapid application development, audio tools and accessibility tools. A summary of these tools is presented next.

4.2.1.1 Rapid Application Development Tools

Macromedia Flash: Macromedia Flash, as discussed in *Chapter 3: Investigating the Learner Profile*, is the main tool used for the development of reinforcers (small games) and lessons. Flash provides the developer with graphic libraries, sounds, fonts and built-in library buttons in order to create animations which meet the needs of the young learner with autism. Flash also has incorporated accessibility features within its software, which provides the developer with additional options to make content more accessible to screen reader software.

Hot Potatoes: Hot Potatoes is a word quiz development software application created by Half-Baked Software (Hot Potatoes, 2008). Hot Potatoes enables the developer to create multiple-choice, crossword puzzles or matching exercises. The application is based on both HTML and JavaScript scripting language. During this initial prototype development the developer had the opportunity to experiment with the different built-in templates within the tool. Modifications were also made to each template in order to fit within the original interface design. This tool provided for the creation of 'drag and drop' matching exercises

which allows for the child learner to have access via the touch screen. This rapid application tool decreased development time which enabled the researcher to create and modify quizzes easily and meet the tutors' deadlines to complete evaluations during specific semester times.

JavaScript: JavaScript is a scripting language which is embedded within HTML pages. It is a client-based code which is processed at run-time within a web browser. The 'Hot Potatoes' tool and JavaScript technology both work together to provide feedback in the form of pop-up messages to the user (Arneil and Holmes, 1999). This in turn can provide for increased user satisfaction as the learner is obtaining automatic feedback and instructions while completing the quiz (Keller, 1987; Keller, 1996; Murray, 2002).

4.2.1.2 Audio and Recording Tools

The following technologies, combined together, allowed for the recording of voice-overs for the tutorial:

Microphone, Windows Sound Recorder, and Switch Sound File Convertor (NCH Software, 2009): The inclusion of the voice-over is a necessity in order to meet the user requirements that arose during fieldwork. The Irish accent, recorded in the voice-over, provides for an easier understanding of the social story. Much of the software available in schools has been developed with non-native intonations. During fieldwork tutors commented that children with autism can have difficulty understanding the non-local terminology and accent. The

addition of the voice-over also acts as a reading assistant as the child can listen to the voice-over in time with the highlighted text.

4.2.1.3 Accessibility Tool

A-Prompt: A-Prompt is web accessibility verification tool developed by The Adaptive Technology Resource Centre in the University of Toronto. The tool enables a developer to upload HTML pages and lists the criteria needed in order for the page to meet the needs of the WAI Guidelines (ATRC, 2002). These guidelines are essential for meeting the accessibility and cognitive needs of the learner.

4.2.2 Lesson Development

During the design phase (documented in *Chapter 3: Investigating the Learner Profile*), after discussions with tutors, it was decided that the theme 'hand washing' would be developed into the online social story. During the concluding stages of the design phase, the researcher created an animated Flash story. The interface features were discussed with tutors and the screen design evaluations received positive feedback. During this phase of development the researcher further expanded on the Flash lesson. A voice-over was recorded and integrated into the lesson in order to provide the learner with additional support when reading the social story.

The Voice-Over

From previous investigations with tutors the inclusion of a voice-over was chosen to assist with the reading and understanding of the lesson.

A microphone and 'Windows Sound Recorder' were used to record the spoken word of the lesson. The package 'Switch Sound File Converter', (NCH Software, 2009) a free online sound file converter, was used to transform the voice file to an mp3 file for easy implementation.

The overall synchronization of the audio file with the Flash movie proved technically challenging for the researcher as it was difficult to keep the voice recording in time with the highlighted text. Numerous recordings were created before a clear, perfectly timed voice-over was created. The voice file was then imported into Flash and integrated into the lesson.

The audio is controlled simultaneously with the 'play' and 'stop' buttons within the lesson. When the user selects the 'stop' button, the Flash animation stops along with the audio. Similarly, when the learner presses 'play' the movie plays again from where it was stopped, along with the audio. There is also a mute button, see Figure 4-2, labelled with a speaker symbol, for turning off the sound.

Figure 4-2 Mute button to control voice-over

This allows the user to watch the movie but also have the option of controlling the sound, providing an adaptable interface to suit different learning preferences and learning styles. These interactive functionalities aim to actively engage the learner in the learning environment (Hardy *et al.*, 2002).

4.2.3 Quiz Development

The objective of the quiz section is to emphasize the main points within each lesson in a relaxed and fun environment. As the quizzes are based on words and sentences, it is also a means to further enhance and develop the verbal and vocabulary skills of the young learner.

As mentioned above the software 'Hot Potatoes' is used to create the quizzes. The 'Hot Potatoes' software has capabilities to support cloze tests (or gap-fill exercises), matching tests and crosswords.

There are three quizzes to choose from within the prototype i.e. matching-pairs, cloze test and sentence maker. Each category of quiz is based on elements found within the lessons topics of the prototype. The learner is provided with the option of choosing a quiz to complete. Whalen *et al.* (2007) emphasise the importance of giving the learner the control for choosing their computer-based quiz or reward.

4.2.3.1 The Guide Tool

The guide tool can be found throughout the quiz section. It is represented as a purple paw graphic located at the right of each screen (see image in Figure 4-3). When the user clicks on the button a pop-up window appears, which provides additional assistance or instructions as to how to complete the quiz. This window remains open, until closed by the user, to assist the user if needed (see screenshot Figure 4-3). It is mainly of use to a tutor or parent who may guide the young learner through the lesson (Mandel, 1997).

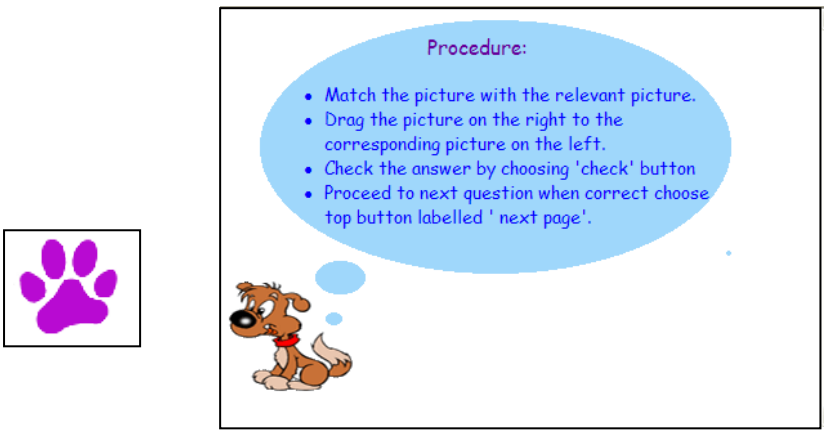


Figure 4-3 The guide tool (represented as a purple paw) and pop-up help screen

4.2.3.2 The Matching-Pairs Exercise

The matching-pairs exercise encourages the learner to create associations between images and words. This exercise requires the learner to drag the box with the printed word to the relevant picture on the left hand side of the screen (see Figure 4-4). When the child has completed the task he can press the 'Check' button to see if the answer is correct. For demonstration purposes, this quiz displays two choices only. As the child

advances, additional images and words can be incorporated into the quiz. Each picture has already appeared in the Flash lesson. By using the same image, the main elements within the lesson are being reinforced for the learner. The child can query if he has matched the pairs correctly by pressing the 'Check' button on the screen. This provides the child with a pop-up information screen, informing the child if he has made a correct decision. This method of immediate feedback allows the learner to create a relationship between the question and given answer (Jordan and Powell, 1995).

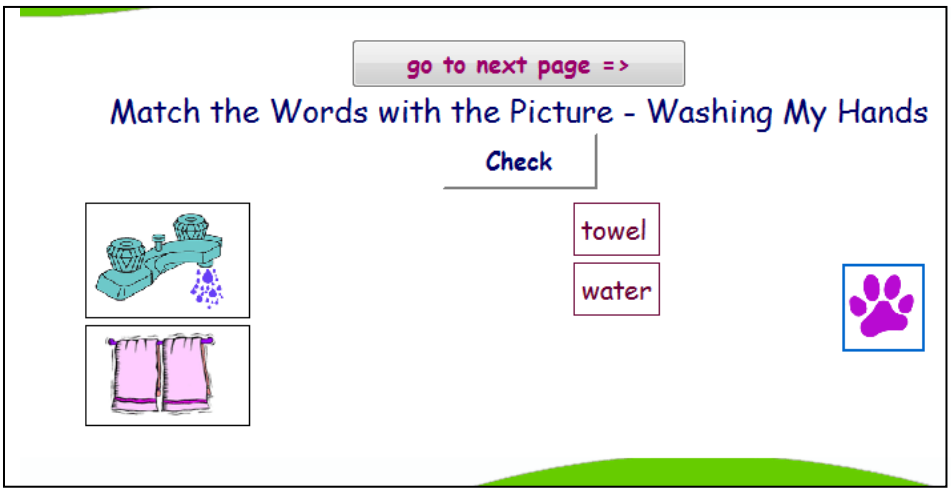


Figure 4-4 Interface for matching pairs quiz for hand washing exercise

The following set of procedures explains how to complete the matching pairs exercise.

1. The learner is presented with two static images on the left side of screen (see Figure 4-4).
2. The learner is also presented with two 'dragable' word boxes.
3. The learner must drag the word box to its corresponding image.
4. The learner repeats this procedure with the remaining word box.

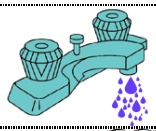
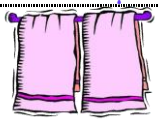
5. When both word boxes and images are paired together the learner can press the 'Check' button to see if his answers are correct.
6. If both answers are correct the learner can press the 'go to next page' link, to complete another matching exercise.

On completion of two screens, the child is presented with a choice of games. This again incorporates the steps of Applied Behaviour Analysis where the learner receives a small reward on completion of a task (Lovaas, 1987).

Matching Pairs: Vocabulary and Graphics

Vocabulary and graphics used within the developed story were reproduced in the quiz to assist in the transfer of knowledge. The combination of these different quiz formats can be seen to engage the learner with autism in a form of parallel processing of the vocabulary (Tjus and Heimann, 2000). Within this prototype the child is presented with a set of pictures and words in order to create an association, as illustrated in Table 4-1.

Table 4-1 Words and graphics for *Washing My Hands* matching exercise

Word:	Graphic:
soap bottle	
bar of soap	
Water	
Towels	

4.2.3.3 Cloze Test or Gap-Fill Exercise

The cloze test or gap-fill exercise includes three sentences reproduced from the *Washing My Hands* lesson. The gap-fill exercise encourages the learner to spell a word, through typing sequences of letters from the keyboard. Figure 4-5 provides a screenshot of the quiz interface.

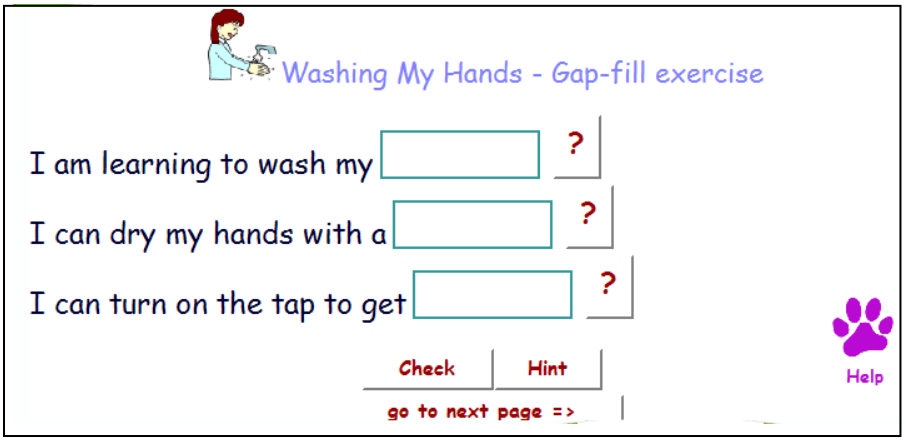


Figure 4-5 Interface for cloze test/gap-fill exercise for washing hands quiz

The following list of procedures details how the gap-fill exercise is completed:

1. The learner is presented with a set of three sentences from the *Washing My Hands* story.
2. A word is omitted from each sentence and replaced with an empty text field.

   An example of a sentence is shown below:

   I am learning to wash my [ ]
3. The learner must type the missing word into the empty text field.
4. The learner can check if the answer is correct by pressing the 'Check' button.
5. The learner can receive a hint, if required, by pressing the '?' symbol. Table 4-2 found below illustrates the missing words and their corresponding hints used in the quiz.
6. If the learner requires a more comprehensive hint, he can press the 'Hint' button at the end of the screen. This places a letter of the missing word into the text field, for example:

   I am learning to wash my [h]
7. The Guide Tool, described earlier, is also present on the screen to provide further assistance to tutors and learners.
8. The learner must complete two screens before receiving the game rewards.

Table 4-2 Missing words and hints within the gap-fill exercise

Word	Hint
Soap	It can be in the shape of bar or it can be in a bottle.
Dirty	Not clean.
Hands	They have fingers on them.
Towel	It stops things being wet. It can be paper or material.
Water	It is wet and a liquid.

Gap-Fill Exercise: Vocabulary and Graphics

A set of six sentences were created using vocabulary from the original *Washing My Hands* story, as recommended by tutors. The repetitive use of the social story sentences and vocabulary in the quiz section can aid in the process of knowledge transfer (Siegel, 2003). The importance of repetition is also reflected in the Applied Behaviour Analysis approach (Lovaas, 1987). This enables the learner to create relationships between the text and graphics. According to The National Council for Curriculum and Assessment (NCCA), receptive and expressive language, reading and writing are important strands within special needs programme development (NCCA, 2002). The quiz reflects this practice by allowing the learner to progress from matching objects to recognising and typing words. The following sentences were selected with tutors:

- I can use soap and water to clean my hands.
- People wash their hands when they are dirty.
- Rub both hands together under the water.
- I am learning to wash my hands.
- I can dry my hands with a towel.

- I can turn on the tap to get water.

As mentioned above, a hint option was included within the prototype which provides further assistance to the learner while completing the quiz. Simple descriptions or explanations of each word to be included within the prototype were discussed with tutors. Table 4-2 shown previously illustrates a list of words along with their hints included in the exercise.

4.2.3.4 Sentence Maker

The sentence maker quiz (see Figure 4-6) also includes sentences from the lesson, as discussed above. Tutors were consulted, prior to design, as to which sentences to include in the quiz. The procedure for the learner to complete the quiz is as follows:

1. The learner is presented with text boxes at the end of the screen.
2. The learner must drag each word onto the blue line, in the correct sequence, in order to complete a sentence.
3. The learner can press the 'Check' button to see if the sentence structure is correct.
4. The 'Restart' button resets the quiz if the learner feels he has made a mistake.
5. The learner receives a reward at the end of the quiz.
6. The Guide Tool is also present throughout the sentence maker section, to provide further support.

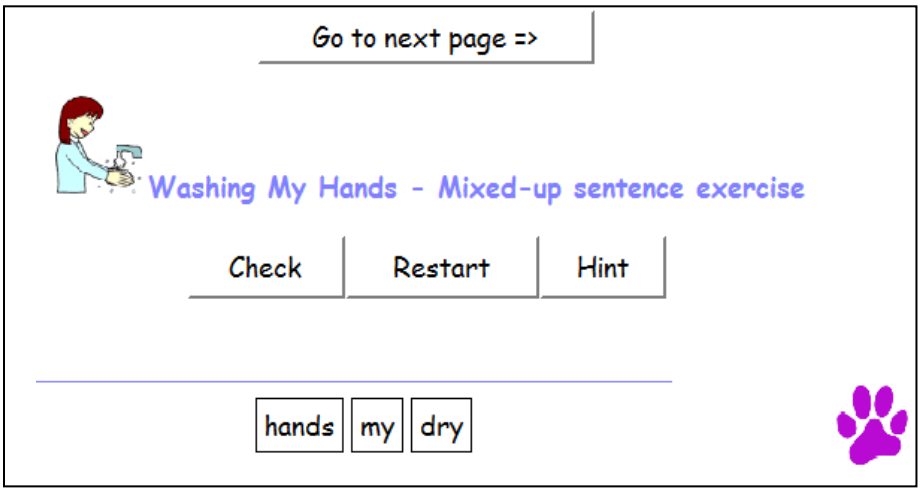


Figure 4-6 Screen interface of sentence maker for washing hands quiz

Mixed-Up Sentence Exercise: Vocabulary

Two sentences are included within this exercise both of which are taken from the original story. These sentences are:

- Rinse the soap off my hands.
- Dry my hands.

The objective of this exercise is to further enhance grammatical skills of young learners, by allowing them to construct meaningful sentences from words. As proposed by Hurewitz and Beals (2008), computer software for learners with autism should teach grammatical phrases as opposed to single words. The exercises within this prototype strive to progress the learner towards this learning level.

4.2.4 Reinforcer Development

4.2.4.1 Background to Reinforcer Usage

Reinforcers are a feature used within the Discrete Trial Instruction (DTI) framework. They can consist of both positive praise, as well as a material reward to reinforce correct behaviours and skills (ICAN, 2000). It is important to choose a reward that the child values as this can increase motivation. However, it is more beneficial to increase motivation and correct behaviour by teaching the child to respond to social praise (Siegel, 2003). Praise and feedback should be provided by the trainer for the learner's efforts (Keller, 1987; Spence, 2003). As stated by Siegel (2003, 121),

> *"The balance between keeping the child motivated, helping the child become self motivated and helping the child work for social praise alone is what moves the child toward a greater degree of independence in the future".*

Reinforcers can be provided at fixed or variable times. Variable timing is known to obtain a greater effort from a learner. As the learner does not know when to expect the reward, variable timing encourages the learner to work harder to receive the reward (Siegel, 2003).

A previous software study, Teach Town, for children with autism, found that children were motivated to complete lessons within the program once they had access to miniature software games upon completion of the lesson (Whalen *et al*., 2007).

4.2.4.2 The Design and Development of Reinforcers

Within the scope of this prototype it was decided to develop a choice of six different games as reinforcers. These games are provided at random throughout the different quiz sections. As previously stated the child learner can choose any one of three games (reinforcers) on completion of any of the quiz sections. Each game is timed to last a maximum of thirty seconds, and when the time has terminated, the game web page re-diverts back to the quiz section. This technique is used to avoid a situation where the child spends too long playing a particular game and tries to avoid returning back to the lesson. A sample reinforcer web page is shown in Figure 4-7.

Figure 4-7 Reinforcer screen where user can choose a reinforcer

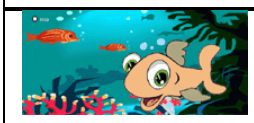
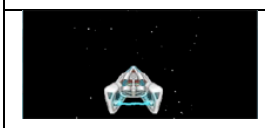
Each game adopts elements observed during fieldwork that children with autism have a tendency to enjoy, as explained in the following subsection.

Multimedia Rewards for Motivation and Engagement

The sea scene and arctic scene reinforcers (shown in Figure 4-7 above) adopt the children's fascination with movement and sound effects. When the child scrolls over a fish or penguin, the object moves and creates an effect similar to that of hand waving or shaking. An unusual cartoon-type sound effect also plays in time with the movement.

Fieldwork findings suggest that young learners enjoy constructive shapes, similar to those found in the alphabet, or moving shapes like bubbles or falling stars on a screen (Grandin, 1995). Another reinforcer combines both these elements where the child is presented with some 2-Dimensional letters of the alphabet and coloured stars falling within each letter. Table 4-3 below documents the six different reinforcers used within the prototype and the reasoning behind the design approach and development of each one.

Table 4-3 Outline of reinforcers

Reinforcer Thumbnail	Details
	Reinforcer incorporates stimming and rapid movement effects when user rolls over objects.
	Reinforcer includes stimming, rapid movement effects and unusual sound effects when user scrolls over objects.
	Reinforcer gives feeling of movement, through moving outer space background image.
	Reinforcer incorporates structured linear effect within its shapes which children with autism take pleasure in.
	This jigsaw allows the learner to explore shapes and linear objects while making a puzzle.
	Reinforcer gives feeling of movement, through falling stars images. The letters A and G also provide the structured linear effect which is enjoyed by many children with autism.

The researcher developed these reinforcers using a combination of multimedia tools discussed earlier.

4.2.5 Progressive Evaluations

Three categories of interface design evaluation were performed to assess the performance and design of the interface. Firstly, the researcher conducted an initial pilot evaluation with an expert user group, where effectiveness of the overall prototype was assessed. Next, the researcher evaluated the accessibility issues of each HTML page in correspondence with the WAI Guidelines (WAI, 2006). Finally, the researcher completed a further evaluation with the local tutors within special needs schools. These three evaluation processes are discussed next.

4.2.5.1 Expert User Evaluation

The researcher conducted a pilot evaluation with an expert user group. The users were asked to complete the *Expert User Interview Questions* found in *Appendix B: Interviews.* The prototype was demonstrated to the group and open comments and feedback were welcomed throughout the presentation.

Findings from the survey indicated that, overall, the prototype was satisfactory. However, as detailed next, some suggestions were made in relation to the voice-over, quiz section and Flash story.

The Voice-Over

The voice-over was found to be clear and comprehensible. Additional observations suggested that an adult voice was appropriate for instructional or procedural stories like hand washing. In general, children can relate to receiving instructions from an adult

such as a teacher or parent, so an adult voice-over for a story like 'washing hands' would be appropriate. A further suggestion indicated that for a non-procedural story such as *Taking Turns* and *Making a New Friend*, a child's voice may be more appropriate, as the child can relate to interacting with another child.

The Quiz

A number of suggestions were recommended for the quiz. It was thought that more use of colour for fonts, similar to the colours used in the story, may be more appealing. The feedback pop-up box could be displayed over the whitespace to the right of the screen, instead of the centre, to avoid blocking the text. The form's text field size could be increased or perhaps a drop-down menu would be easier to navigate. The guide tool (symbolised as the paw) was also commented upon as being an additional benefit, as it provided more detailed assistance depending on the verbal level of the child.

Flash Story

Overall, the social story, *Washing My Hands*, received a positive response. Additional comments, made in respect of the button size for 'play', 'stop' and 'mute', suggested that their size could be increased slightly to accommodate for the use of the touch screen.

4.2.5.2 WAI Guidelines Evaluation

Throughout the design and structure of the prototype the developer aimed to abide by the guidelines set out by the W3C (see *Chapter 2: Literature Review*) to make each web

page accessible for users with special needs (WAI, 2006). In order to provide all necessary checks, the researcher downloaded web accessibility software, known as A-Prompt, developed by the Adaptive Technology Resource Centre (ATRC, 2002).

Assessment of web pages using A-Prompt accessibility tool

All web pages, which were to be accessed later in the national online study, were uploaded to the A-Prompt tool for accessibility assessment. Figure 4-8 below provides a screenshot of the list of pages tested for this study.

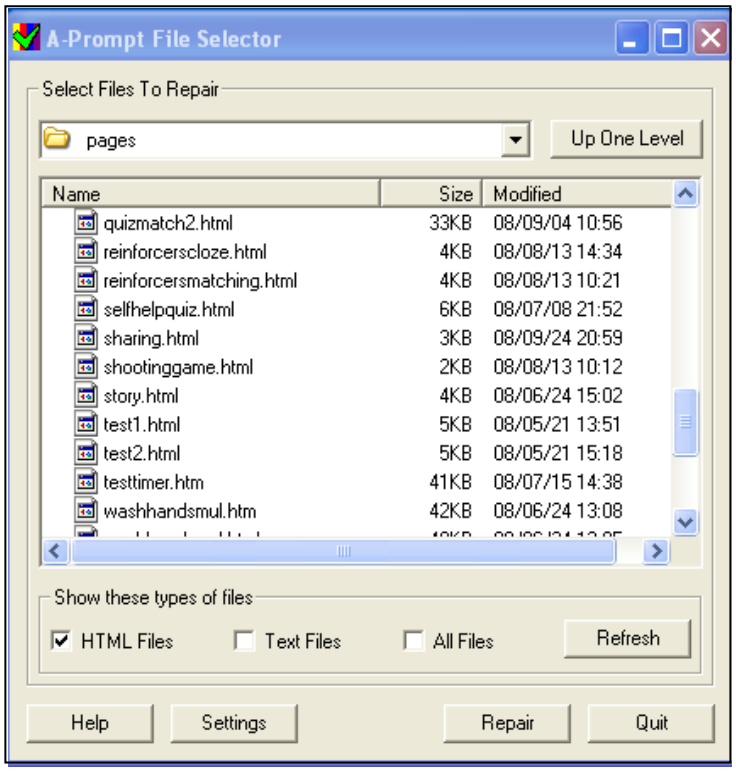


Figure 4-8 Screen image of pages uploaded in A-Prompt software

When a single HTML page is selected, the software runs a scan of the page and reports a set of WAI Guideline accessibility faults. Upon completion of a check on the 'story.html' webpage, the A-Prompt software reported nine issues preventing accessibility of the webpage, illustrated in Figure 4-9. As each subsequent page was checked, it was found that the issues reported in Figure 4-9 were common across the other web pages.

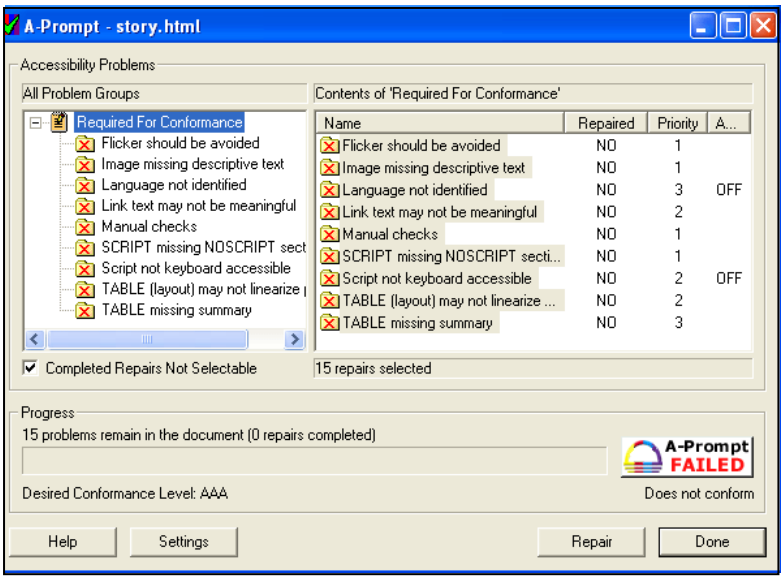


Figure 4-9 Screen image listing accessibility problems of 'story.html' page

The main issues are summarised as follows:

- *Screen flicker must be avoided:* This is a manual check by the developer to ensure that there is no flickering or flashing images on the webpage.
- *Image missing descriptive text:* This problem states that an image within the web page is missing an 'alt tag' or 'longdesc tag'. The software prompts the developer to insert the relevant text in order to describe the image (see Figure

4-10). The purpose of 'alt tags' or 'longdesc tags' is to provide additional information in place of non-text items which cannot load to a window, such as an image. They also provide additional descriptions for screen readers which can describe verbally what is displayed on the screen.

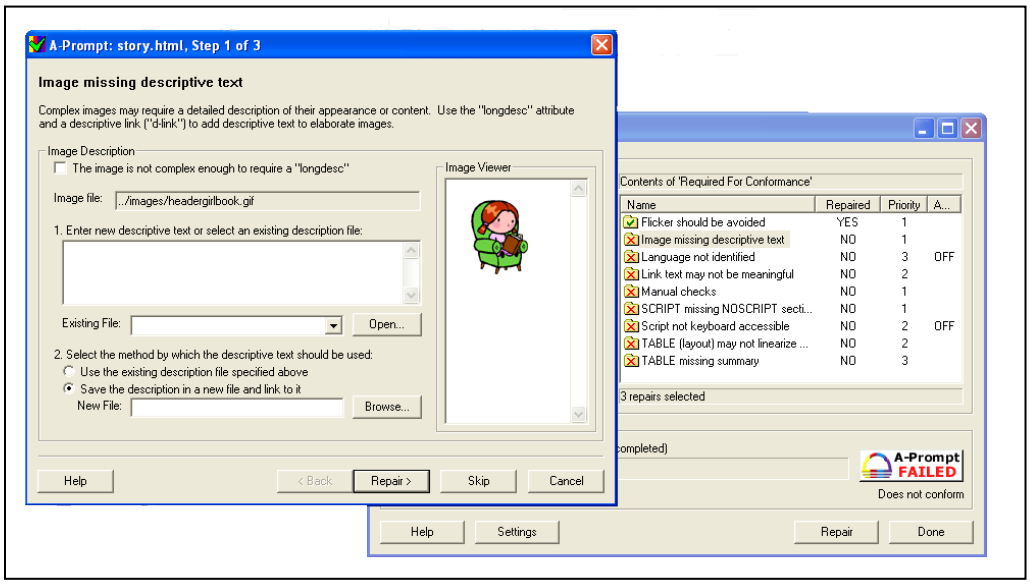


Figure 4-10 Screen image highlighting an *image missing descriptive text* guideline

- *Language not identified:* Each web page must declare the language used within the HTML code in its header i.e. EN for English.
- *Link text may not be meaningful:* If there is a link or anchor within the webpage, and if the link is not obvious e.g. an image link, significant text must be displayed in place of the link. Again, the software prompts a further window for the developer to insert text for the link.
- *Manual checks:* The software lists a number of manual checks that the developer must avoid on each page.

- Colour only should not be used to convey information.
- Programs and scripts must be accessible.
- Web pages should still be useable when embedded programs like applets are disabled.
- All program objects require a text equivalent which will be displayed if the program object is not available. A line of text describing the program and its content should be displayed in the HTML page if the program is not able to run.

- *SCRIPT missing NOSCRIPT section:* The 'noscript' section contains a body of text which describes what the scripting language contains and what it is used for. This detail is usually displayed if the user's web browser cannot run scripts.
- *Script not keyboard accessible:* The software provides keyboard alternatives in order to make scripts accessible, as an alternative to access from the mouse.
- *TABLE (layout may not linearize properly):* The rows in the table must still remain intelligible if they are linearized. The software presents the table to you in a linearized fashion and enables the option to edit the table if it is incomprehensible. The table within the 'story.html' page is used for display of graphics, hence it is intelligible when viewed in a linearized display. If a web browser cannot support tables, the user can still interpret the content within the rows and columns correctly. This also provides additional information to screen readers to translate the information within the table to the user.
- *TABLE missing summary:* The table is missing a description or summary, to describe information the table is carrying. In the case of this table, it is entirely used for layout of graphics and not for display of information.

All the pages within the prototype were validated and corrected prior to the tutor evaluation in School A.

The A-Prompt software was an important tool used during development to emphasize significant accessibility errors which may have been overlooked during design and development. The tool enabled further accessibility for special needs learners mainly through increasing the access features of each page to screen readers. Many of the special needs learners are nonverbal or have lower reading levels. This additional feature allows the web content to become more comprehensible to special needs learners.

4.2.5.3 Tutor Evaluation

A third evaluation of the prototype was carried out in School A. The prototype was demonstrated to the tutor by the researcher and a prototype evaluation questionnaire, found in *Appendix B: Interviews*, was presented to the tutor.

Findings from the evaluation found that the graphics, navigation, fonts and use of colour were all of a high standard within the prototype. The choice of reinforcers is of good variety and the thirty seconds timer on each reinforcer is of an appropriate length. The tutor also suggested that the inclusion of the timer on each game could encourage the child to become more motivated to go back and complete a quiz again in order to gain another reward. Reinforcers, similar to the jigsaw, are also good at stimulating a child's use of memory. The children may be encouraged to remember where each piece goes. When they have the chance of choosing the jigsaw puzzle again, they can be forced to

use their memory to remember where the jigsaw pieces go in order to complete the quiz within the thirty second time interval.

The Quiz

During the evaluation of the quiz, the tutor provided the researcher with additional suggestions for further development. Overall the quiz section meets the needs of various levels of the autistic range of abilities and works on memory and progressing vocabulary skills.

- *Matching-Pairs:* The 'matching-pairs' quiz can be used with learners with mild to moderate autism and learning difficulties. In order to progress a child's reading skills it was suggested to further subdivide the matching-pairs exercise in a similar manner to that of the reading curriculum (NCCA, 2002). Firstly, the learner must match a picture with a picture. Later the word is introduced along with the picture. Next the learner must match a word to a picture and finally match a word to a word. Figure 4-11 illustrates the matching-pairs screen (this image was seen earlier as Figure 4-4).

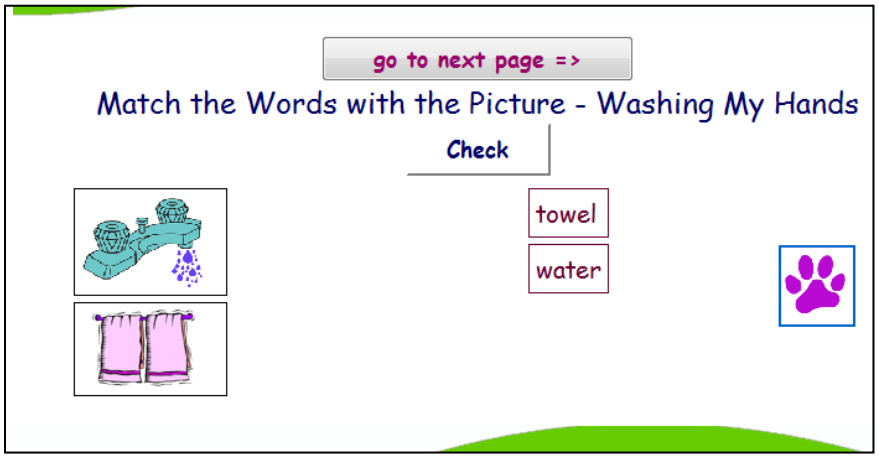


Figure 4-11 Screen of matching-pairs quiz for hand washing exercise

- *Cloze Test:* In respect of a learner with autism along with special needs, the cloze test would be best to commence with the use of graphics instead of words to be substituted into the sentence in order to fill in the missing word. Gradually, the learner could progress to substituting words instead of graphics. However, a more highly functioning learner with autism would benefit more from the use of text instead of graphics in order to progress vocabulary skills. The text hints, discussed earlier and seen in Table 4-2, would be of more benefit in a graphical form as opposed to a text format for a learner with autism and special needs. However, the higher functioning learner with autism may find the text hints of more benefit than the graphics, according to the tutor.
- *Pop-Up Feedback Boxes:* Instead of the phrases 'Well done' or 'Try Again' the inclusion of smiley and sad faces may be more appropriate for informing the learner (Read *et al.*, 2002).

Overall the tutor agreed upon the theme of washing hands and its evolution into a quiz as being appropriate and universal for different learners with autism and special needs. The prototype can be incorporated into the classroom curriculum and the social story can be operated easily and independently by the learner. The quiz section can encourage interaction between a supervisor and student. Each program can be adapted by the supervisor to meet the needs of the individual. The print option, shown in Figure 4-12, also reinforces this idea as teachers can create worksheets from the story and quiz.

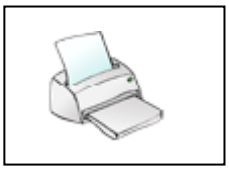


Figure 4-12 Printer icon

Revisions to prototype

Following the feedback received from the tutor evaluation, the researcher implemented revisions to the prototype. The matching-pairs quiz and feedback boxes were prioritized as two key areas to be improved upon within the prototype.

Matching-Pairs Exercise: Further Improvements

To respond to feedback three stages were introduced within the matching-pairs exercise i.e. that of beginner, intermediate and advanced level. These three stages reflect the steps used in progressive reading levels of young learners (NCCA, 2002).

- *Beginner/Stage 1*: The first steps taken when teaching a child to read is through matching pictures, in order for the child to associate the object with the spoken word. Therefore, in the 'beginner' section of the quiz the child is presented with two pairs of pictures. The learner is required to drag the picture to the corresponding correct picture.
- *Intermediate/Stage 2:* The next stage within reading progression is to introduce the written word (text) along with the corresponding picture. Within the 'intermediate' section of the quiz, the learner is presented with two images along with two corresponding text boxes. The learner must drag the text box to the corresponding picture in order to complete the quiz.
- *Advanced/Stage 3:* The final stage of reading progression is to identify individual words. During the advanced stage the child is presented with two pairs of text boxes. The learner must be able to identify the matching text boxes by dragging each text box to its corresponding text box.

Feedback: Further Improvements

The addition of smiley face graphics was introduced into the design of the pop-up feedback, as recommended by the tutor. Within the classroom, the children are already familiar with receiving this token through stickers and stamps after they complete a task. As shown in Figure 4-13 a sad face appears as feedback when the child incorrectly matches the pairs. Read et *al.* (2002) discuss the design of different types of smiley faces in their 'Smileyometer' tool. Two faces were used in the prototype i.e. 'happy' and 'sad'.

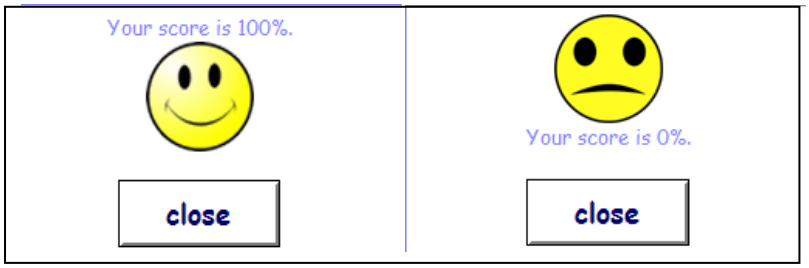


Figure 4-13 Screenshot highlighting graphical feedback from exercise

4.3 Concluding Remarks

This chapter discusses the design and development of the three major components within the prototype, the lesson, the quiz and the reinforcers. The task analysis and user profiling conducted during the primary phases of this research combined with theoretical knowledge and technologies, has produced a learning scenario suited to special needs learners. The prototype underwent evaluations from expert users and tutors. Each web page contained within the prototype underwent thorough web accessibility tests, to ensure it adhered to the guidelines set out by the WAI (WAI, 2006). A variety of multimodal features such as audio, graphics and tactile hardware (switch and touchscreen) were also integrated in the prototype development.

Feedback and advice from these evaluations led to some minor redesigns of the prototype. The prototype was then ready to be available online for a nationwide evaluation. The next chapter (*Chapter 5: Prototype Evaluation*) documents the survey and evaluation of the prototype.

5. Chapter Five: Prototype Evaluation

5.1 Introduction

The concluding findings from *Chapter 4: Accessibility and Usability in Lesson Development* showed a positive response from tutors towards the prototype. Now that the prototype had been approved by local tutors, the next phase of evaluation was to upload the prototype, along with a corresponding survey, to a web server in order to perform a national evaluation. A number of special needs schools were chosen at random to participate in the survey. A questionnaire, consisting of software usability and design questions, was created in both online and paper-based format and distributed to the schools.

Within this chapter, findings and feedback from the survey are evaluated. Any problem areas in the prototype are highlighted and investigated. Improvements are then implemented into the prototype in order to reflect user feedback. This is the final phase of Mayhew's (1999) lifecycle, referred to as installation. Table 5-1 documents the list of events which occurred during the online evaluation stages.

Table 5-1 Summary of events for online evaluation

List of Events	
Step 1	Prototype is uploaded to online web server.
Step 2	Quarterly account is created with SurveyMonkey (2009) online survey tool.
Step 3	Random sample is chosen of special needs and autism schools in Ireland.
Step 4	Survey packs are issued to schools.
Step 5	Reminders are issued to schools.
Step 6	Statistician is consulted about survey feedback.
Step 7	Survey data is analyzed in SPSS statistical package.
Step 8	Rework on prototype, to address feedback.

5.2 Random Sampling

A random sample of special needs schools in all counties of Ireland (Republic) was chosen to participate in the survey. A detailed list of special needs schools and schools with special classes was retrieved from the Department of Education and Science website (Department of Education and Science, 2008).

From this spreadsheet the researcher restricted the list to include only schools and classes which catered for:

- Special schools with children on the autistic spectrum.
- Special classes with children on the autistic spectrum.
- Primary schools with early intervention classes for autism.
- Primary school special schools with early intervention classes for autism.

After this selection was made there remained a list of 115 schools. The researcher then scanned the data to search for a list of schools by county. Counties which had only one school with special needs were added to the survey list. A random sample was then performed on the counties which had more than one special needs school in the list. Each odd-numbered school in the county was selected and added to the list. The final selection resulted in a total of 62 special needs schools that were then invited to participate in the survey.

The aim of this sampling approach was to contact approximately 50% of special schools in each county. The table below, Table 5-2, summarises the steps used during the schools' selection.

Table 5-2 Sampling approach during school selection

Sampling Approach	
County with one school	School 1 was selected
County with two schools	School 1was selected
County with three schools	Schools 1 and 3 were selected
County with four schools	Schools 1 and 3 were selected
County with five schools	Schools 1, 3 and 5 were selected
County with six schools	Schools 1, 3 and 5 were selected
County with seven schools	Schools 1, 3, 5 and 7 were selected
County with eight schools	Schools 1, 3, 5 and 7 were selected

A survey pack was issued to each of the 62 special needs schools. A brief introductory letter was written to each principal, which consisted of a short overview of the project and survey, and also seeking permission to allow teachers to participate in the study. A more detailed letter was written to teachers, outlining the background to the study and

providing instructions as to how to use the prototype. Finally, a printed version of the survey was attached for those who preferred to respond to the survey by post instead of online. A reminder letter was issued to schools following a three-week period to prompt teachers to return the survey if they had not already done so. Both letters and a copy of the survey are included in *Appendix C: Survey & Statistical Analysis*.

5.3 Questionnaire

As stated above the researcher decided upon both an online questionnaire and printed questionnaire to cater for different respondent preferences (see *Appendix C: Survey & Statistical Analysis*). The online version of the questionnaire was hosted using the online survey tool SurveyMonkey (SurveyMonkey, 2009). The researcher registered for a quarterly subscription to the tool which included a set of templates for easy creation and editing of the survey, a web address that respondents could visit to take the survey, and storage facilities where all responses were stored securely online and could be downloaded easily in spreadsheet format. The questionnaire was composed of 28 questions, 23 of which were rated using a 5 point Likert Scale and 5 allowed for additional comments. The selection of questions within the questionnaire reflects usability themes such as learnability, effectiveness and efficiency (Preece *et al.*, 2007). Accessibility features were also considered in the design of the survey. The questionnaire was divided into five main sections:

- General questions on the prototype environment.

- General questions on the lesson.
- General questions on the quiz.
- General questions on the reinforcers.
- Additional comments.

The overall results received from the survey provided a positive response in relation to the different aspects within the prototype. A total of 21 respondents replied to the survey, 8 via the SurveyMonkey tool and 13 questionnaires were returned by post. One of the paper-based surveys was discarded due to incomplete responses, so this left a total of 20 questionnaires to complete our analysis. This equated to a response rate of 33.3% which, given the busy routine in a special needs classroom, we considered to be a reasonably satisfactory rate.

The researcher consulted the college statistician to discuss the results received and to receive advice on analysing the questionnaire results. Statistical analysis was carried out using SPSS. A series of tables and charts where created in order to provide a statistical summary of the survey responses. Next, we discuss feedback received under each survey category. We present a relevant subset of the data analysis in chart and table format. Remaining results are included in *Appendix C: Survey & Statistical Analysis.*

5.3.1 Section A: General questions on the prototype environment

Question 2A How effective are the graphics within the prototype?

The results from Question 2A, highlighted in the barchart in Figure 5-1, show that:

- 15% found the graphics of an ‘excellent’ standard.
- 45% found the graphics of a ‘good’ standard.
- 30% agreed that the graphics were ‘ok’.
- 10% found the graphics to be of a ‘weak’ standard.

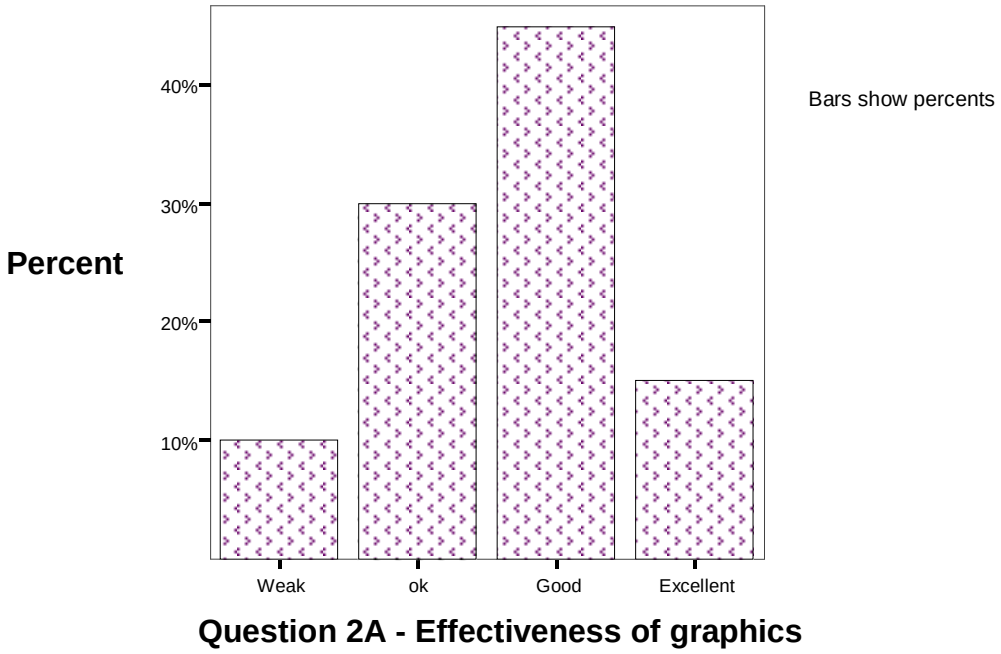


Figure 5-1 Barchart representing effectiveness of graphics

Overall, these results show that the majority of respondents were satisfied with the graphics, with only 10% considering the graphics as ‘weak’.

Question 5A How would you rate the ease-of-use of the program for the target audience?

The results from Question 5A, represented diagrammatically in Figure 5-2, show that:

- 11.1% thought that the ease-of-use of the program was 'excellent'.
- 44.4% were in agreement that ease-of-use was 'good' within the program.
- 16.7% gave an 'ok' response.
- 22.2% found the ease-of-use to be 'weak'.
- 5.6% thought the ease-of-use of the program was 'unacceptable'.

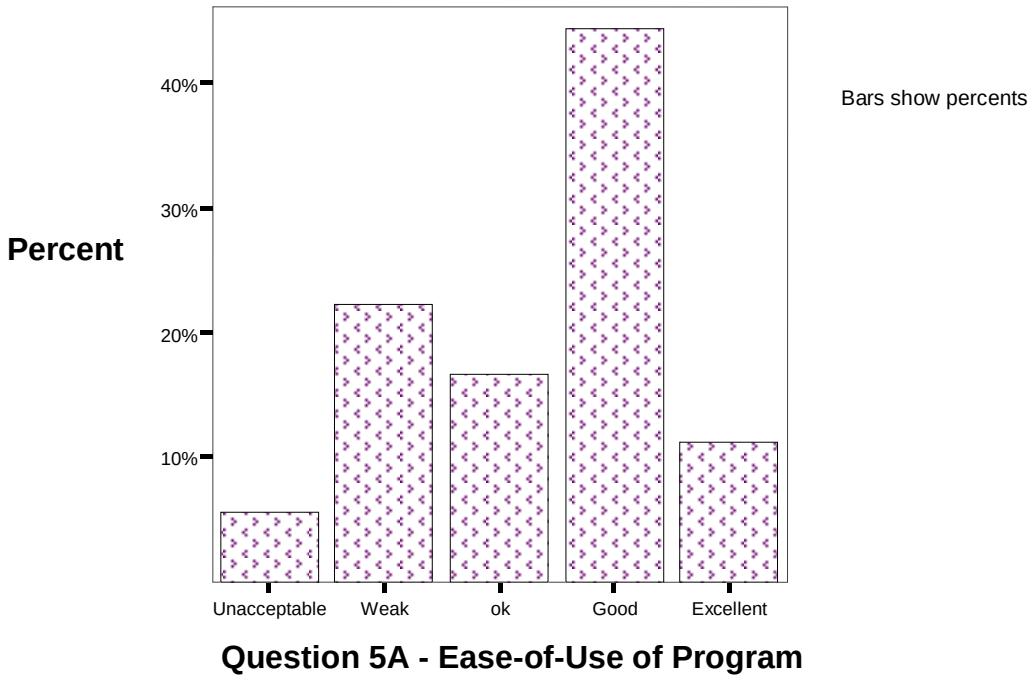


Figure 5-2 Barchart representing the ease-of-use of the program

A small majority of respondents, 55.5%, were in agreement that the program was easy-to-use, with a further 16.7% finding the ease-of-use to be in the 'ok' category.

Question 7A How navigable is the navigation menu (i.e. Home, Lesson, Quiz Buttons) for the target audience?

Tutors' feedback, which is documented in Table 5-3, showed us that:

- 20% of tutors agreed that the navigation was of an 'excellent' standard.
- 50% felt that navigation was 'good'.
- 15% thought that the navigation buttons were 'ok'.
- 10% found the navigation 'weak'.
- 5% saw the navigation as 'unacceptable'.

Table 5-3 Summary of statistics showing tutors opinions of the navigation menu

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Unacceptable	1	5.0	5.0	5.0
	Weak	2	10.0	10.0	15.0
	Ok	3	15.0	15.0	30.0
	Good	10	50.0	50.0	80.0
	Excellent	4	20.0	20.0	100.0
	Total	20	100.0	100.0	

The majority, 70%, agreed that the navigation buttons were navigable by the target audience.

More questions and responses corresponding to colour, suitability of vocabulary, appropriateness for class curriculum and effectiveness of the pop-up help option can be found in *Appendix C: Survey & Statistical Analysis*.

These further findings can be summarised as follows:

- The majority of respondents, 75%, found the use of colour effective within the prototype, while 5% found the colour to be weak.
- Approximately 57.9% of tutors found the vocabulary suitable within the prototype.
- 45% of tutors thought that the prototype would be 'ok' within their classroom curriculum, while another 45% found the prototype to be 'good or excellent'.
- Regarding the 'help' option, 44.5% found the feedback effective while 33.3% found the help option weak.

5.3.2 Section B: General questions on the lesson

Question 1B How legible is the font (Comic Sans) within the lesson?

Table 5-4 represents a description of respondents' reactions, which can be summarized as follows:

- 35% of respondents deemed the font as 'excellent'.
- The remaining 65% found the Comic Sans font to be of a 'good' standard for legibility.

Table 5-4 Table representing the legibility of the Comic Sans font

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Good	13	65.0	65.0	65.0
	Excellent	7	35.0	35.0	100.0
	Total	20	100.0	100.0	

Therefore, all the respondents showed positive reactions towards the Comic Sans font within the program.

Question 5B How would you rate the benefits in social skills for the students who use this lesson?

The majority of respondents considered that the program could have positive benefits on the social skills development of young learners (see Figure 5-3).

- 30% of respondents thought the social skills lesson was ‘excellent’.
- 40% of responses received resulted in the benefits of the social skills lesson been thought of as ‘good’.
- 20% of teachers gave an ‘ok’ response.
- The remaining 10% thought the software program was ‘weak’ at providing training for social skills development.

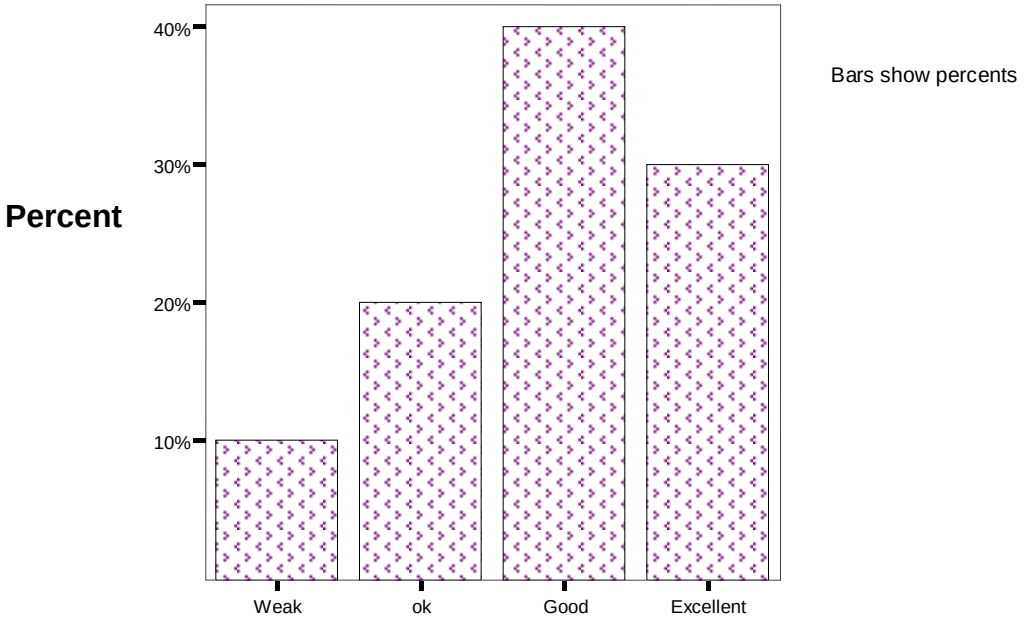


Figure 5-3 Barchart representing benefits of prototype for social skills

The response on the whole has shown that respondents were satisfied with the program.

Further questions in relation to the effectiveness of the voice-over and control buttons can be found in *Appendix C: Survey & Statistical Analysis*. These finding are outlined as follows:

- The majority of respondents, 90%, found the font size appropriate.
- Most of the tutors, 73.7% thought the voice-over was effective.
- Overall, 63.2% of tutors found the voice-over comprehensible.
- 60% of tutors found the buttons easy to control.

5.3.3 Section C: General questions on the quiz

Question 6C How navigable are the navigation buttons in the quiz for the target audience?

- 15% considered the quiz navigation buttons to be of an 'excellent' standard.
- 40% of respondents rated the buttons to be of a 'good' standard.
- Another 40% of respondents agreed that the navigation buttons were of an 'ok' standard.
- 5% of respondents thought that navigation was 'unacceptable'.

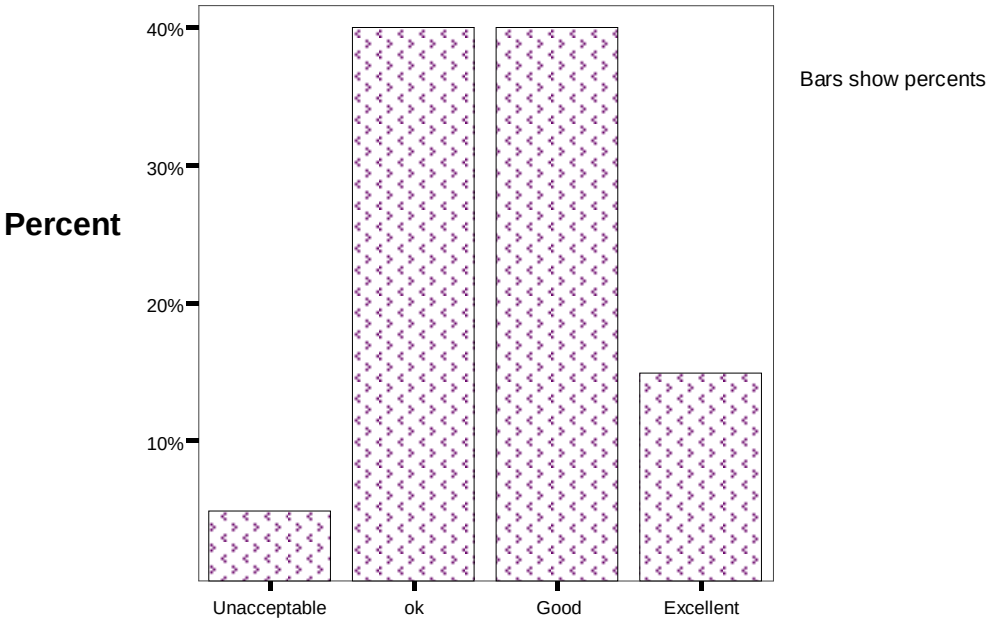


Figure 5-4 Barchart representing respondents' opinions of quiz buttons

Respondents' feedback on the quiz navigation buttons showed an equal opinion between 'ok' and 'good', as represented in Figure 5-4. On the whole, feedback in relation to quiz navigation can be said to be positive.

Question 7C How would you rate the feedback provided throughout each quiz (i.e. pop-up messages)?

Half of the respondents surveyed considered the feedback to be of an 'ok' standard, as shown in Figure 5-5. In relation to the other 50% surveyed, the majority responded towards the positive end of the scale with either a 'good' or 'excellent' rating, with the remaining 10% considering the feedback to be 'weak' or 'unacceptable'.

- 15% of teachers surveyed thought the feedback was 'excellent'.
- 25% of teachers thought the feedback was of a 'good' standard.
- 50% of respondents considered the feedback as 'ok'.
- 5% of teachers considered the feedback to be 'weak'.
- The remaining 5% found the feedback to be 'unacceptable'.

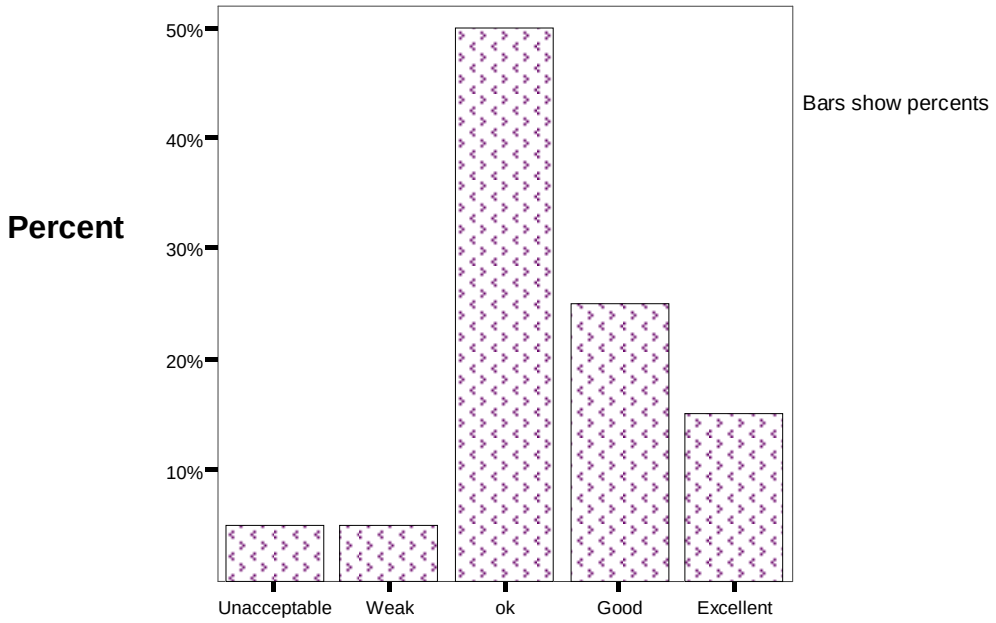


Figure 5-5 Diagram of the respondents' reactions to feedback

Overall, the response rate is pointing towards the positive end of the scale with the majority of respondents deeming feedback as 'ok'.

Further questions in relation to the suitability of the cloze test and matching-pairs quiz found that 40% of tutors rated the quizzes as 'good', while 30% of tutors found the sentence maker quiz to be either 'ok' or 'good'. Also, 50% of tutors found the rate of progression within the quizzes to be of a 'good' standard. These questions and responses are documented also in *Appendix C: Survey & Statistical Analysis.*

5.3.4 Section D: General questions on the reinforcers

Question 2D How motivating is the choice of reinforcers (miniature Flash games)?

A breakdown of respondents' choices is listed below, while a statistical description of results is shown in Table 5-5.

- 5.3% of teachers thought the reinforcers (flash games) were of an 'excellent' standard.
- 15.8% of teachers thought the reinforcers were of a 'good' standard.
- 52.6% considered the choice of reinforcers as 'ok'.
- 15.8% thought the reinforcers were 'weak'.
- 10.5% considered the reinforcers as 'unacceptable'.

Table 5-5 Respondents' responses to motivational value of reinforcers

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Unacceptable	2	10.0	10.5	10.5
	Weak	3	15.0	15.8	26.3
	Ok	10	50.0	52.6	78.9
	Good	3	15.0	15.8	94.7
	Excellent	1	5.0	5.3	100.0
	Total	19	95.0	100.0	
Missing	System	1	5.0		
Total		20	100.0		

The majority of respondents agreed that the motivational value of rewards could be rated as 'ok', with a further 21% falling in the 'good' or 'excellent' categories.

Further reinforcer findings detailed that:

- 42.1% of tutors found the reward role of flash games as positive upon completion of a lesson, while 36.8% deemed the games as 'ok'.
- There was an equivalent finding of 42.1%, in which tutors thought the frequency of reinforcers as 'positive', while another 42.1% found the frequency as 'ok'.

Statistical tables representing these findings can be found in *Appendix C: Survey & Statistical Analysis.*

5.3.5 Section E: Additional comments

An additional five open-ended questions were supplied at the end of the questionnaire in order to receive supplementary feedback in relation to the prototype. We now outline advice and responses received for each of the five questions.

- ***Question 1E*** *What improvements or suggestions can you recommend in relation to the prototype?*

  Recommendations and improvements were suggested from teachers for different aspects of the prototype. One suggestion for the voice-over proposed that the speed of the voice-over could be adjusted to meet the needs of children with different levels of reading skills. The possibility of applying the prototype to further skills like dressing skills was also suggested. One teacher recommended shortening the story to a list of steps or cues for example:

Step 1: Dirty Hands

Step 2: Sleeves Up

Step 3: Clean Hands.

The use of a video recording of a child washing her hands was proposed as being suitable for a class of older children. The option of personalization was recommended so that the child could input her name into the story. One teacher commented:

> *"If it was possible, it would be nice to be able to insert the pupil's name instead of 'I' and 'people'. In any social story activity we use in school it is important to personalize it so that the child can relate to it."*

- ***Question 2E*** *What do you like about the prototype?*

  The feedback in response to this question provided very positive comments towards the simple design of the interface, graphics, colour and ease-of-use. Teachers also complimented the overall theme of the prototype and commented on how difficult it is to find suitable software to teach social skills. Two of the responses received are reproduced below:

  > *"The graphics are lovely. The navigation buttons (home, stories, quiz) are well presented and very suitable. The voice-over functionality is very useful and clear. A wide variety of social skills could be taught with this application. The hint buttons (hint, ?) are very helpful. Good feedback."*

A second response states:

> *"I like the layout of the pages and the ease of navigation around the site. When choosing software for children with ASD, we always note the layout and design so that it's not too 'busy' or over-stimulating. This prototype has a nice layout that is easy on the eye and simple to follow."*

- ***Question 3E*** *What do you dislike about the prototype?*

  One teacher advised that the level of reinforcers (Flash games) could be advanced to meet different levels for each individual learner. Another comment suggested that the fish and birds in the reinforcers may upset young children. The scrollover in the Flash games might not be suitable for children with epilepsy. Finally, a teacher concluded that the voice-over was monotone and found the social story to be abstract and far too long.

- ***Question 4E*** *Are there additional features that you would like to see added?*

  Some of the additional features requested reflected the comments received in Question 1E about further improvements to the prototype. Personalization, video and an increase in the selection of social stories were suggested. Further features advised were a text-to-speech facility for all the text on the screen or the inclusion of voice and sound throughout the prototype, to read all the text on menus and screens to the child. A further comment from a teacher asked:

  > *"Video stories/demonstrations of social stories. A text-to-speech facility for all text on the screen. It might be more appropriate to select level of difficulty before quiz choice. Is it possible to have user profile to save preferences and records of work/progress?"*

- ***Question 5E*** *Have you any further comments?*

  Overall, responses were positive towards an online adaptation of the social stories. The teachers found the hand-washing exercise to be very useful. It was thought that it would be beneficial to also adapt the stories to post-primary level as it is difficult to find software to teach skills to teenagers.

  > *"I enjoyed using this prototype and it is great to see someone considering the target audience's needs. If this was an interactive prototype where teachers could add pupil's own name and perhaps photos to make social stories relevant and personal it would be an invaluable asset to any classroom for children with ASD. Thank you for this opportunity."*

5.4 Further Prototype Development

We now summarise the tutors' suggestions for further development of the prototype and outline our responses. A total of seven features were recommended as possible improvements for different aspects of the prototype:

- *Wider selection of stories:* Tutors thought that the addition of more stories, such as dressing skills, could be added to the prototype. Due to the scope and time limits of the project, the researcher needed to focus on one story to be used as a sample and as a basis for tutor feedback.

However, future development could integrate more stories based on feedback received from the *Washing My Hands* prototype.

- *Real photographs:* The inclusion of real photographs was suggested which may suit older learners or teenagers with autism. As this research project was purely investigating animations, we did not wish to widen the investigation to photographs, due to time constraints and facilities available to the researcher. Also, we were focusing our investigations principally on very young primary school learners, aged from four to nine years of age. However, future developers creating software for an older audience could consider the use of photographs.
- *Personalization/Virtual Learning Environment:* The personalization option was recommended by the majority of tutors. Children or their tutors could enter children's names and personal information and this could then be reflected in the story. The inclusion of a backend database for storing tutor details and progress was requested by teachers. For our investigation, this additional feature proved to be outside the scope of this project as the researcher was primarily investigating interface and accessibility guidelines. Previous research in the Teachtown autism project included investigations into this particular area (Whalen *et al.*, 2007). Further development could include this feature to further advance the quiz and reinforcer section.

5.4.1 Final Prototype Revisions

Both text-to-speech facilities and video, where considered as further design features which could be added to this prototype. These two options were selected from the tutor feedback and the prototype was revised in an effort to respond to a subset of tutor suggestions. This phase represents the final step of Mayhew's (1999) Usability Lifecycle, as illustrated below in Figure 5-6.

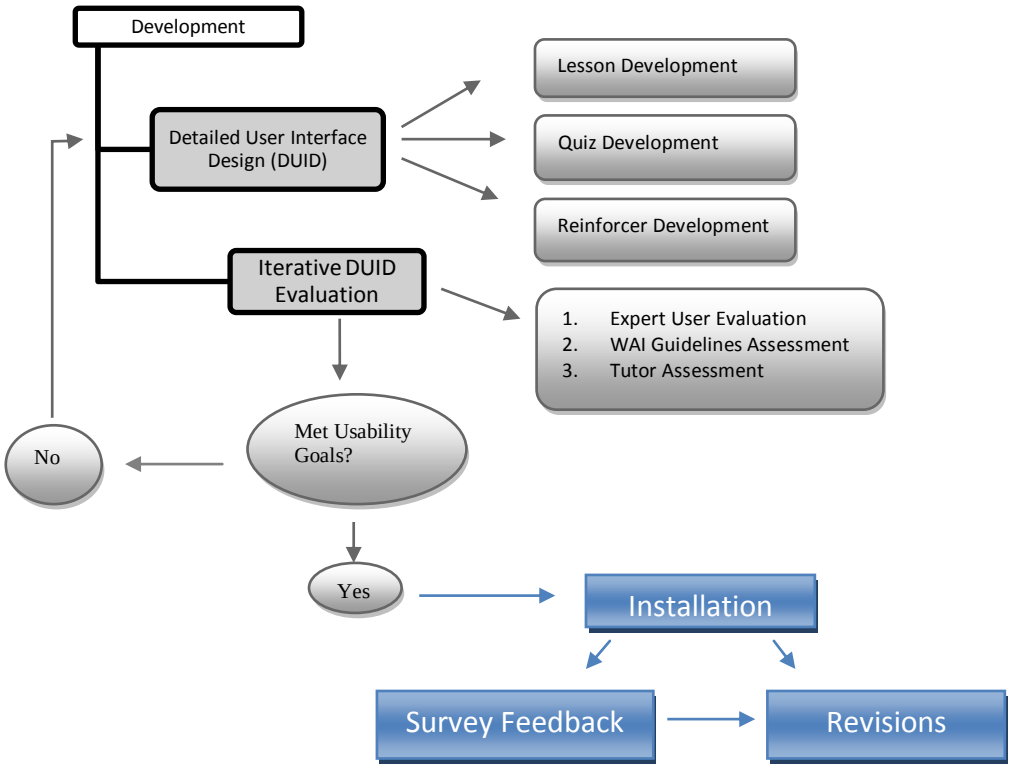


Figure 5-6 Prototype installation (adapted from Mayhew, 1999)

Text-to-Speech Facility

It was requested to include a text-to-speech facility to cover all text areas of the prototype. Due to the timeframe of this investigation, it was not possible to redevelop all the web pages within the prototype to include speech or voice-over. However, the researcher performed a test on all web pages of the prototype to see if they were compatible with text-to-speech software.

For this investigation 'Read & Write Gold Mobile' software from Texthelp systems was selected (Texthelp, 2009). The software allowed for easy installation via a USB Drive. Upon installation, a floating toolbar appears as shown in Figure 5-7.

Figure 5-7 Floating toolbar for Read & Write software

The floating toolbar is accessible from different software such as Microsoft Office, PDF files or HTML pages. For convenience the prototype was accessed through Internet Explorer, to provide for easy integration with the 'Read and Write' software. As shown in Figure 5-8 the 'Read and Write' toolbar was placed simply above the web page text near the top of the webpage. All text on the screen was highlighted using an input device such as a mouse. Next the 'Play' button, shown as a green right pointing arrow, was pressed. All the highlighted text on the screen was then read back to the user.

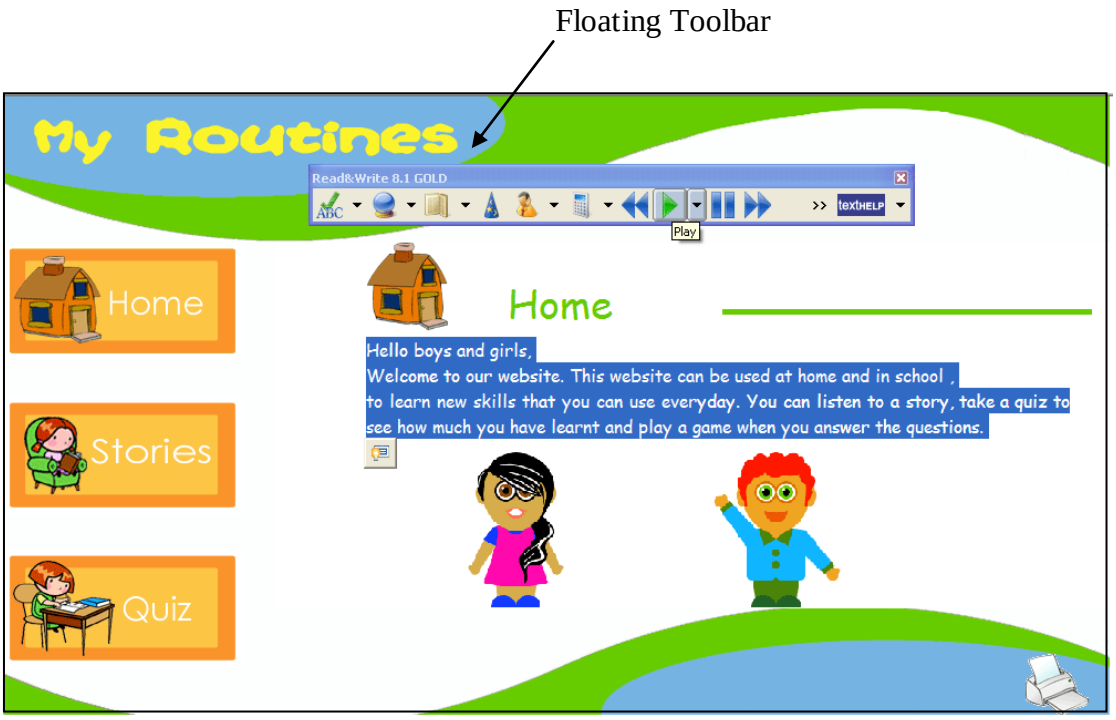


Figure 5-8 Screenshot of Read and Write software tested on the prototype

This process was repeated with the remaining quiz html pages. The speech reader clearly rendered all the text displayed on the pages. The software also provided additional personalized options such as a variety of voices and choice of text colour combinations to be displayed when highlighting the text. Overall the investigation showed that not only is the prototype compatible with text-to-speech software, but that this type of software is convenient for providing voice when the voice-over alternative is not always present.

Video Recording of Social Scenario

A further finding from the evaluation indicated that the inclusion of a video recorded version of the social scenario could be another additional feature to include within the prototype. The use of the video as opposed to animations would suit older students within the class as they may find video recordings more interesting and appealing than cartoon animations.

Video recordings could also incorporate the 'Personalization' aspect discussed earlier. Children with autism in the class could be recorded demonstrating a social skill such as washing their hands. Then the video could be uploaded to the prototype. The child can then relate the action and skill by observing himself completing the task in the video.

For this inquiry, a primary school learner was recruited for the recording. Prior to any recording, the learner was shown the social story *Washing My Hands*. Next an adult demonstrated the skill for the learner. The learner repeated the task and was recorded using a small inconspicuous camcorder (see Figure 5-9). The video was then transferred onto a laptop for editing using a USB cable.

Figure 5-9 Video recording of child washing his hands

The video recording was embedded into a HTML page and uploaded with the rest of the prototype. A link was presented, alongside the original multimedia animation, which could be chosen by the learner if he required a viewing of the video instruction.

5.5 Tools and Technologies Evaluation

A number of different tools and technologies where used during the different phases of the prototype development. There were mainly two sets of technologies: those for web development; and secondly, tools to evaluate the end product (see Table 5-6).

Table 5-6 List of Technologies

Web Development tools	Evaluation tools
Macromedia Dreamweaver	A-Prompt
Macromedia Flash	SurveyMonkey
Hot Potatoes	

5.5.1 Web Development Tools

- *Macromedia Dreamweaver:* Dreamweaver is an easy-to-use technology which is built on HTML to allow effortless creation of web pages. Images and animations can be embedded into web content smoothly. Overall this package is straightforward and meets the standards required to create this prototype.
- *Macromedia Flash:* Flash allows for the easy creation of web animations. The voice-over and graphics were easily integrated into the *Washing My Hands* lesson.

  There were also various drawbacks of Flash which were encountered during development. During the creation of the social scenario, Flash did not provide for re-usability for some of the objects used within the animation. If another social scenario animation was to be created the highlighted text and some of the graphics would have to be recreated.

  Another problem encountered with Flash was in relation to its timeline. If additional features were added to the story, the voice-over would be placed out of synch with the rest of the animation. To overcome this problem a new recording of the voice-over would have to be created.

- *Hot Potatoes:* The Hot Potatoes (2008) tool is also built using HTML and JavaScript allowing for easy integration. Many of the templates within the software provided for easy formatting of quizzes. However the quiz page templates could also be customized by the developer to fit into the overall prototype design.

  The Hot Potatoes (2008) technology also presented some difficulties during development. As the code was written by other developers it was difficult to read and manipulate at different stages. Removal of some blocks of code, which seemed unnecessary to the developer, prevented other aspects of the quiz from working. Even though the developer had previous experience of CSS and JavaScript, Hot Potatoes was sometimes unpredictable and might not be ideal for non-programmers.

5.5.2 Evaluation Tools

- *A-Prompt:* A-Prompt (ATRC, 2002) is an online Web Accessibility Tool which tests pages to see if they meet the WAI standards (WAI, 2006). The upload tool was straightforward for the researcher to upload pages of the prototype. The advice and actions that needed to be taken on each page to meet web accessibility standards were also clearly explained.

  This tool provided for sufficient accessibility tests required for this research. However, due to the software being an 'Open-Source' technology, much of the additional features available on the market are not included. Also, as the WCAG 2.0 (2008) guidelines were only announced in mid December 2008, it is likely

that much software on the market is not yet compliant or updated to respond to the new guidelines.

IBM's industry standard technology called the 'Rational Test Policy' (IBM, 2008) includes supplementary accessibility tests such as parsing Flash files, the Children's Online Privacy Protection Act check, and complete computer-based guideline checking, as opposed to manual guideline checking. The computer-based guideline checking avoids errors or oversights that may happen with manual checking.

- *SurveyMonkey:* SurveyMonkey (2009), the online survey tool, provided for easy creation of the online survey. Its online storage facility also displayed respondents' feedback clearly. Overall SurveyMonkey (2009), upon payment of a subscription fee, makes data handling and survey management easy. However, the tool is lacking in in-depth data analysis functions, even though it can convert the data into spreadsheet format. Also another drawback of the tool is its online storage facility, as the data can become inaccessible if the web server is unavailable. Downloads of the survey responses have to be completed on a routine basis.

In conclusion, the researcher encountered no major difficulties in using any of these technologies. Each technology was proficient in meeting the requirements of the prototype at each respective phase.

5.6 Concluding Remarks

Generally, the prototype was well received among the teachers of autism class groups and in special needs schools. The interface and design aspects of the prototype were regarded positively in most cases. Its clutter-free and minimalistic design provided easy navigation for the young learner, as tutors' replies to the open questions highlighted. The theme of the online social story was also commented upon as being a constructive approach for teaching social skills to young learners, as well as advancing their reading skills.

Overall, the online prototype evaluation provided a strengthened set of recommendations, summarized under the aspects of:

- Interface design
- Accessibility features
- Computer-based learning support
- Multimodal components.

These findings are discussed further in the following chapter, *Chapter 6: Conclusions*.

6. Chapter Six: Conclusions

6.1 Introduction

This body of research aimed to create a multimedia-based social skills lesson for young learners with autism. A thorough investigation of these users' computer needs, and learning requirements, would establish a development framework. This framework would then be used as a foundation for creating the computer-based lesson. This software would follow both educational and online accessibility guidelines in order to ensure a productive learning environment. However, a further analysis would seek to improve upon these existing industry accessibility guidelines to meet the cognitive and usability needs of the user with autism. The conclusions of this research are now presented in the following sections.

6.2 Research Aims and Objectives

The aims and objectives of this research have been discussed previously in *Chapter 1: Introduction*. The research questions are summarized as follows:

1. Is there evidence to suggest that a multimedia-based instructional program can be developed which can assist in the social development of the young learner with autism?
2. Using the framework of the developed prototype, what are the criteria for improving on the existing industry guidelines for web and software accessibility in relation to the user with autism?

Also, the research objectives are restated and summarized below:

- To create a user profile of the child learner with autism and use this model as a basis for developing a multimedia-based instructional lesson.
- To consult and evaluate the user model with tutors during development phases.
- To develop a multimedia-based instructional prototype that incorporates the use of social routines as a software learning environment to support the social and educational development of learners with special needs. The software must include a special emphasis on relevant accessibility issues.
- To liaise with tutors and learners during development of the prototype and encourage the tutor and learner to test and evaluate the prototype, thus incorporating a 'user-centred' design approach.

We now discuss our findings as they relate to these research questions and objectives.

6.3 Findings, Observations and Research Results

The main aim of this project was to create a user profile based on the requirements of the child learner with autism, and use this profile to build a multimedia prototype to enhance social skills development. As stated in our first research question we intended to investigate the following statement, '*is there evidence to suggest that a multimedia-based instructional program can be developed which can assist in the social development of the young learner with autism?'.*

Throughout this research, each phase of development was discussed and evaluated with special needs tutors. On completion of the end-prototype, a national evaluation was undertaken with special needs tutors in Ireland. A total of 70% of tutors agreed that this prototype could be beneficial at enhancing the social skills development of children in their classroom. The feedback received from the open-ended questions also contained positive observations in relation to the social skills assistance that the prototype provided. One comment stated: *'A wide variety of social skills could be taught with this application'*.

Our second question intended to answer the following statement: *'Using the framework of the developed prototype, what are the criteria for improving on the existing industry guidelines for web and software accessibility in relation to the user with autism?'*. The results in *Chapter 5: Prototype Evaluation* indicated that there were four areas that could be recommended as areas of improvement for future software design for our target audience. These are interface design, accessibility features, computer-based learning support and increased use of multimodal components.

6.3.1 Interface Design

Overall it was found that learners with autism require a clear, clutter-free, and easy to navigate interface to assist with their online learning needs. Large navigation buttons which can be operated by a mouse, touch screen and switch were found to be the best navigation options. A font such as Comic Sans is considered the most appropriate font for reading from the screen. Continuous feedback, in the form of pop-up messages or

smiley faces, is required as encouragement and support for the learner. These elements can be found throughout the different sections of the lesson.

6.3.2 Accessibility Features

Tutor interviews also suggested that there is a lack of suitable computer-based learning software for learners with autism. It was found that Irish-based autism software is required as opposed to European or American based software. Children with autism often find it difficult to understand the non-native accent and terminology. Tutors have found it difficult to source age appropriate accessible software, and as a lot of software is targeted at a wide age range, much of the software can be too juvenile for learners. The theme of our software prototype, i.e. social skills development, was concluded by tutors as being beneficial in the classroom, as there is a very small range of social skills software on the market.

6.3.3 Computer-Based Learning Support

Our further results have shown that the option of computer-based quizzes is an effective approach for reinforcing learning. In the case of this research the word and vocabulary quiz not only reinforced the themes and instructions within the social story but also contributed to enhancing the vocabulary skills of the learner. Additional assistance through the 'Guide Tool' feature is also provided to the tutors. Tutors receive fast on-the-screen guidance as opposed to checking a paper-based manual or completing an

online help search. However, our survey results reflected that approximately 45% of tutors surveyed found the 'Guide Tool' or 'Help Option' to be of the 'ok' category. This highlighted that additional improvements could be made to the 'help' feature, in order to improve upon its support role. When completing our survey we did not request the learning level of each child in the tutors' classroom (i.e. if children had mild, moderate or severe autism). In order to meet these requirements, further investigations could be completed into supporting these different learning levels.

The learners also receive immediate onscreen feedback via the 'check' and 'hint' buttons. This enables the learners to create clear associations between the question and feedback while viewing both, on the screen, at the same time.

The receipt of the game (reinforcer), at the end of the quiz, rewards the learners for their efforts and provides them with a feeling of achievement. By providing games that the learners enjoy, they should become more motivated to complete online lessons. The tutors' responses in relation to the motivational role and frequency of reinforcers (flash games) both fell in the 'ok' category. This reflects that more study needs to be undertaken, in the design of computer-based reinforcers. As mentioned above we did not request the category of learner each tutor dealt with (i.e. mild, moderate or severe autism), so each level could also be investigated further, on an individual basis, in order to create a suitable personalized computer-based reward.

It was concluded that the computer-based approach to teaching social skills was well received by both instructional technology experts and school tutors. Many of the comments received from the national survey showed a positive response towards the

software. Some tutors suggested enhancements in order for it to be more readily implementable in their classroom.

6.3.4 Multimodal Components

We have concluded, from our fieldwork, development and survey, that a variety of multimodal components are necessary both during the design of special needs software, and later when the software is made accessible to the young learner. A multimodal framework was created through a combination of special needs hardware and software features. Our multimodal framework, as illustrated in Figure 6-1, adopts the following elements: Auditory; Tactile; and Visual (W3C Multimodal Interaction Framework, 2003; Preece *et al.*, 2007, 271).

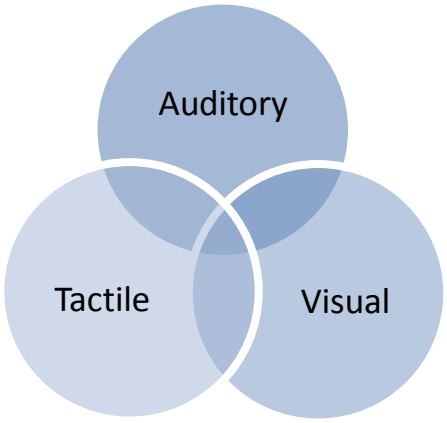


Figure 6-1 Components of multimodal framework

6.3.4.1 Auditory

The voice-over feature was implemented into the social scenario lesson, to enhance learners' reading skills. An Irish intonation was recorded to alleviate the problem that learners were experiencing with American and European based technologies.

6.3.4.2 Tactile

The design of the software was created to cater for a variety of input components: touch screen, switch, mouse, and keyboard. However, local tutors and parents stressed how important it was that learners should become less dependent upon touch screens and switches and should progress to input devices such as keyboard and mouse. The quiz section strives to meet these requirements by providing a variety of quizzes suitable for different hardware components. For example the matching pairs quiz is suitable for touch screen whereas the cloze test requires the learner to type the word via a keyboard. The additional print feature in the quiz section can also be used to allow a child the option of practising his handwriting skills.

6.3.4.3 Visual

A variety of graphics were used within the social skills story and quiz section to provide for the visual senses of the learner. The combination of instructions with corresponding graphics helps to relieve the cognitive load of the learner, and helps make connections

between the instruction and physical action required to carry out the instruction (Howlin, 1998; Shneiderman, 1998; Siegel, 2003).

The highlighting of text within the social skills lesson also targets the learners' reading skills. As the text changes colour in time with the voice-over, the learner can relate the pronunciation of the written word with the spoken word. Depending on the user's preference, a mute button is included so the learner can watch the lesson without listening to the audio.

In summary, this research has achieved the objectives of providing an accessible, multimedia-based lesson that incorporates appropriate multimodal aspects to engage and support the young learners and reward their efforts.

6.4 Research Limitations

There were a number of limitations that this research encountered:

- During completion of fieldwork, class access issues were a limitation on this project. Observational work, development and evaluations of the prototype had to be centred around school term times. Due to staffing issues in schools, tutors were not always available on specific days or times for interviews.
- As a sole researcher, and due to time constraints, it was technically challenging for the researcher to investigate and receive training in all of the different

multimedia animation technologies available on the market which would be suitable to this project.

6.5 Further Prototype Developments

Further areas of development as regards the prototype could be:

- Additional social skills themes
- Personalization
- Lesson and student progression storage facility

Firstly, other themes could be modelled on the prototype to further enhance social skills development. Due to time constraints, the researcher only had time to develop one social story with an accompanying quiz. However, a variety of skills could be based on our prototype approach such as dining skills or dressing skills.

The option of personalization within the prototype could enhance the young child's learning experience. Different types of personalization could be included within the software. The child or tutor could input personal details, such as names, into the story. Videos or photographs of the learner could be included in the prototype so the learner could see himself performing the skill and relate more to the instruction while learning the story.

A lesson and student progression storage facility could be included via a backend database. Tutors or parents could log on to see how many lessons the student has taken

or view the student's up-to-date scores. Tutors could also compare skills and lesson progression by looking at the different test scores. However this environment is related to a full virtual learning environment (VLE) similar to commercially available VLEs.

6.6 Future Technology Trends

Alternative development approaches could include:

- Virtual Reality
- Robotics

Virtual Reality:

The use of virtual reality and virtual environments is an alternative approach for educating learners with autism. A virtual environment can be seen as a safe haven for learners to practise and experiment with social interactions through avatars which they may not have the confidence to do in real life (Moore *et al.*, 2000; Moore *et al.*, 2005).

Virtual environments also allow the user to perform a social task or routine repetitively, through avatars, which would otherwise be exhaustive or monotonous to complete with a tutor or parent (Parsons and Mitchell, 2002).

With the rise of virtual environments such as Second Life (Rymaszewski *et al.*, 2008), these methods can be seen as a motivating and an alternative technique to teach learners with autism in the future.

Robotics:

The use of robots could be a positive approach to allow young learners with autism to practise and engage in social skills. Robotic technology can also be deemed to be a positive approach for learners to explore facial recognition.

Recently, an investigation with a robot known as 'Shybot' was completed (Lee *et al.*, 2008). The aim of the study was to allow the child with autism to learn both social and emotional skills through playing with the robot. The robot's main feature was to demonstrate different actions during various states of shyness depending on how well the robot knew the person with whom it was interacting.

A child-sized robot named 'Kaspar' also aims to encourage social interactions from learners with autism. The robot features include eye, hand and head movement in order to encourage social interactions from the learner (Robins *et al.*, 2009). This opens up a whole new method of users and robots engaging in different social interactions.

6.7 Personal Achievements

Completing this research has provided the researcher with a more thorough understanding of software design and accessibility issues. The researcher was also given an added insight into design requirements and features for children with special needs.

Over the course of this research the author has had the opportunity to discuss and present work with peers and colleagues. A list of these opportunities is summarized below:

- Presented work to colleagues in e-learning and multimedia fields.
- Presented a short paper at the IADIS International IHCI Conference in Amsterdam, Holland in July 2008. Details of the abstract can be seen in *Appendix D: Publications*.
- Presented a poster at the ALT-C 2008 Conference in Leeds, England in September 2008 (see *Appendix D: Publications*).
- Presented a short paper at the iHCI Conference in Cork, Ireland in September 2008 (see *Appendix D: Publications*).
- Presented a short paper virtually at the m-ICTE Conference, in Lisbon, Portugal in April 2009 (see *Appendix D: Publications*).
- Presented a short paper at the Edtech Conference in Dublin, May 2009 (see *Appendix D: Publications*).

The researcher has also had the opportunity of working and meeting with tutors and young learners in the field. These visitations provided for a first-hand look at how children with autism work and play with computers within their classroom environment. It has given an insight and understanding into the problems and issues that many young learners have in accessing computer software. The researcher is grateful for having had the opportunity to investigate and explore some of these issues.

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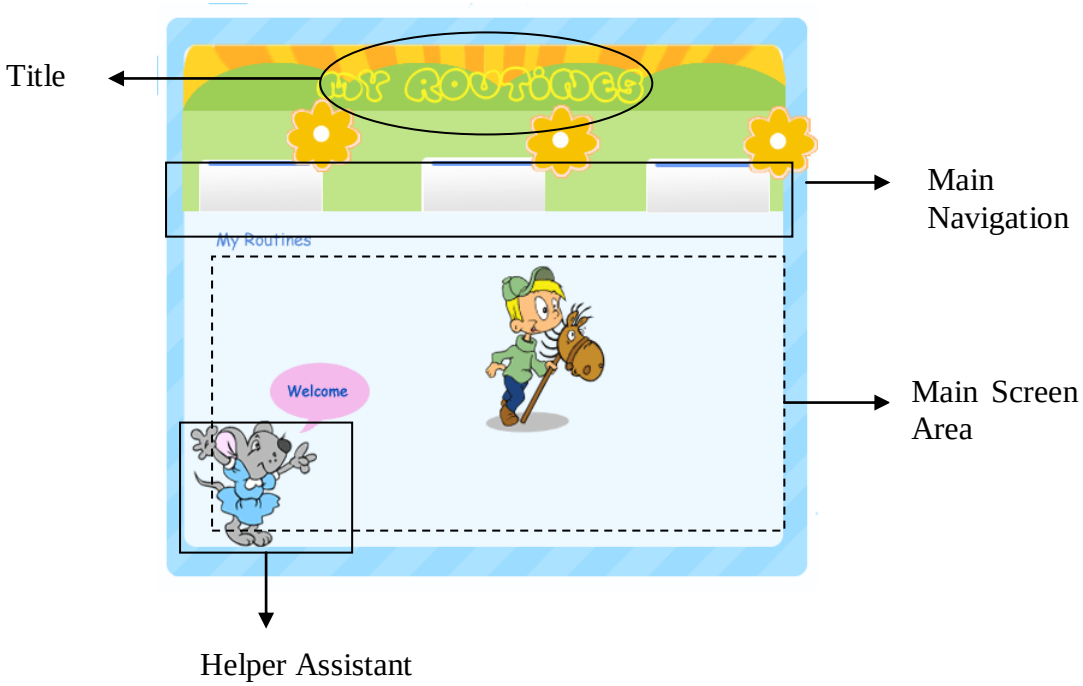
8. Appendices

Appendix A: Storyboard Screenshots

Screenshot: Storyboard 1



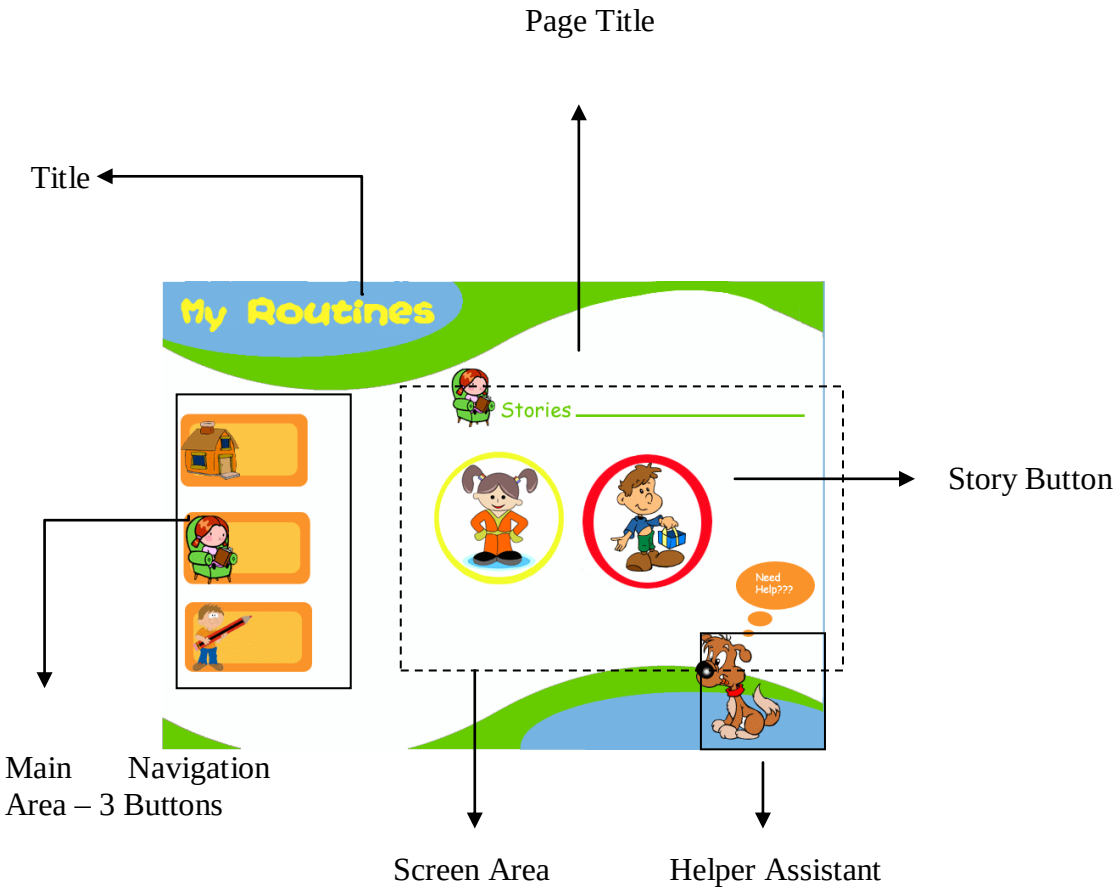
Storyboard Description[1]

- *Title:* The title located at the top of the screen indicates the name of the overall program 'My Routines'.
- *Main Navigation Area:* The main navigation area includes the three buttons which, when clicked on, would enable the user to navigate between the different sections of the program.
- *Main Screen Area:* The main screen area displays the body of web content.

[1] Graphics used throughout all storyboarding, screen design and prototyping were retrieved from Clipart, http://www.clipart.com/en/ and Open Clip Art Library - http://www.openclipart.org/. The 'My Routines' typeface is The Plastic Tomato Font developed by David Kellam at www.eightface.com .

- *Helper Assistant:* The helper assistant, when clicked on, provides additional assistance or information in relation to the screen that the user is currently viewing.

Screenshot: Storyboard 2

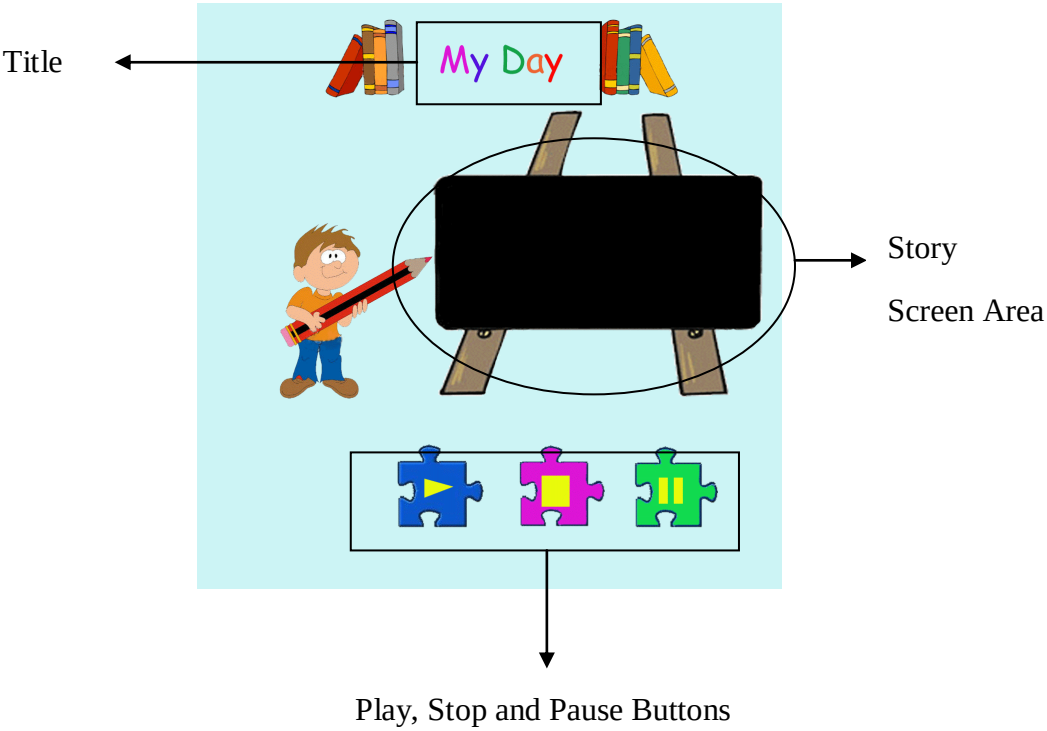


Storyboard Description:

- *Title:* The title located at the top-left side of the screen indicates the name of the overall program 'My Routines'.
- *Page Title:* The page title indicates the name of the section or web page that the user is currently viewing.
- *Story Button:* The story button links the user to the corresponding social story animation.
- *Main Navigation:* The main navigation area includes the three buttons which, when clicked, on would enable the user to navigate between the different sections of the program.
- *Screen Area:* The screen area displays the body of web content.

- *Helper Assistant:* The helper assistant, when clicked on, provides additional assistance or information in relation to the screen that the user is currently viewing.

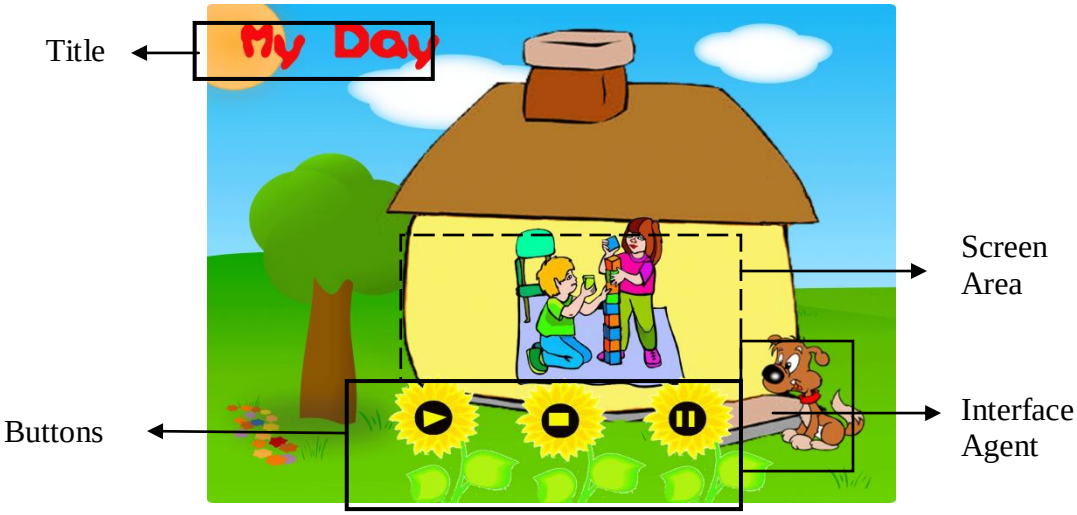
Screenshot: Storyboard 3



Storyboard Description:

- *Title:* The title at the top of the screen indicates the name of the social skill lesson 'My Day'.
- *Story Screen Area:* The story screen area, which displays within the blackboard image, presents the flash animation of the social story.
- *Play, Stop and Pause Buttons:* The play, stop and pause buttons control the flash movie.

Screenshot: Storyboard 4



Storyboard Description

- *Title:* The title at the top–left side of the screen indicates the name of the social skill lesson 'My Day'.
- *Story Screen Area:* The story screen area, which displays within the house image, presents the flash animation of the social story.
- *Buttons:* The play, stop and pause buttons, depicted as sunflowers, control the flash movie.
- *Interface Agent:* When the user scrolls over the interface agent, the agent displays additional assistance or information in relation to the content in the screen area which the user is viewing.

Appendix B: Interviews

Tutor Interview Questions: Task and Requirements Analysis

The following questions were asked to tutors during the early requirements analysis stages:

Navigation

- Are menus more effective at the side or top of the screen?
- What is the most effective size for buttons?
- Should rollover buttons be used?

Universal Symbols and Icons

- Do children understand a) the use of text, b) the use of a symbolic image, or c) a combination of both a and b in order to navigate buttons/menus etc?
- Do children recognize windows menu symbols/icons such as X to close a window? 
- Or universal symbols like the pause button? 

Fonts

- Should font size be increased from standard size?

Audio

- Would voice-overs/background audio be effective?

Colour

- Do children have a preference over the colours used in fonts etc.?

- If so, would it be beneficial to provide an option to change the background colour to suit their needs?

Social Story Topics

- What topics would be most suitable to include in the stories? Home issues, school issues?
- Should stories be gender specific?

Screens/Windows

- How many screens/windows can a child navigate and cope with easily?

Interface Agent

- Should software include an interface agent?

Additional Comments?

Tutor Interview Questions: Evaluation of Storyboards

The questions below were asked of tutors during the mock-up stages of interface. A series of paper-based prototypes (see Appendix A: Storyboard Screenshots) were presented to tutors and a series of accompanying questions were asked.

Questions for Storyboard 1 (refer to *Appendix A:Storyboard Screenshots*)

- Are the buttons' location along the top of screen easy to locate and navigable?
- Should there be a limit on the amount of buttons on a screen?
- Should the buttons have rollover, or are rollovers too distracting?
- Should there be text on the buttons?
- Should the stories display on the main screen or open in a different window?
- Would the integration of a helper agent (like a cartoon mouse) be effective?

Questions for Storyboard 2 (refer to *Appendix A:Storyboard Screenshots*)

- Are buttons easy to navigate and locate on the side of the screen?
- Should stories display in the white area or open in a new window?
- Should stories be gender specific i.e. stories for boys showing boy animations or stories for girls showing girl animations?

Questions for Storyboard 3 (refer to *Appendix A:Storyboard Screenshots*)

- Would it be effective to display the stories within an image like the house similar to the image displayed in the storyboard?

- Is the incorporation of picture backgrounds too distracting or too busy for the learner?

Questions for Storyboard 4 (refer to *Appendix A:Storyboard Screenshots*)

- Would the story be effective within the blackboard image or is it too busy or distracting?
- Would children understand the use of the three buttons play, stop and pause?

Tutor Interview Questions: Interface Design Evaluation

The onscreen interface design was presented the tutor. The tutor was allow explore the interface on the screen and was then presented with the questions below:

Stories Topics:

- Are the topics, sharing and washing hands suitable themes to enhance the social skills of the children?

Lesson/Story (Screen 2):

- Is the lesson interface i.e. colours and choice of graphics appropriate for the theme of the lesson and story?
- Is the choice of colour (white and pastel blue) appropriate?
- Is the choice of colours and size of the font used clear for the learner?
- How much text is appropriate to be displayed per screen?
- Is language and choice of questions within the lesson beneficial to the learner or could it be phrased in a better context?
- During the procedural steps for washing hands lesson in order to enhance learning[2]:

    1. Should the graphics appear first and fade out, then display written text and lastly display graphic again?
    2. Should the graphic appear throughout the written procedure?

[2] Three demos were displayed to interviewee to enhance this point.

3. Or should the graphic appear after the written procedure?

Music

- In your opinion, would you think the option of gentle background music such as Mozart could have a positive effect for the user?
- Have you ever noted the children showing a preference to a certain style/type of music?
- Have you ever noticed a positive or negative attitude towards sounds attached to onscreen buttons?

Reinforcers

- Do you think the reinforcer demos would have a motivating effect on the child to complete a lesson?
- Do you think the child would enjoy the reinforcers?
- Have you come across other computer-based reinforcers that had a positive experience for the child?

Expert User Group Interview Questions: Interface Design Evaluation

The flash social scenario and interface, with working navigation, was presented to the expert user group. A series of questions were then asked in relation to the prototype:

- What improvements/suggestions can you recommend in relation to this prototype?
- What do you like about the prototype?
- What do you dislike about the prototype?
- Are there any additional features that you would like to see added?
- Do you have any additional comments?

One-to-One Tutor Evaluation Questionnaire: Prototype Evaluation

Upon completion of the developed, fully functional prototype an expert user and tutor evaluation was conducted. The following questionnaire was first piloted with expert users, prior to the tutor evaluation and was also used in the national evaluation (see Appendix C: Survey and Statistical Analysis for the online version):

Tutor Details:

Name:

School:

Address:

Grade/Year of Class Taught:

Date:

***'My Routines'* Prototype Evaluation Questions:**

Please tick the box corresponding to your choice in the above menu

General Questions on the Prototype:

Is the use of colour within the prototype effective?				
Are the graphics within the prototype relevant?				
Is the use of vocabulary within the prototype suitable for the target audience?				
Can this prototype be integrated into the class curriculum?				
Can the target audience operate the program with ease?				
Does the Help option meet users needs effectively?				
Is the navigation menu (i.e. Home, Lesson, Quiz buttons) operable?				

	Unacceptable	Weak	OK	Good	Excellent
Questions on the Lesson:					
Is the font (Comic Sans) legible within the lesson?					
Is the size of each font appropriate?					
Is the choice of colour for each word clear?					
Are the graphics effective within the lesson?					
Are the three control buttons (i.e. Play, Stop and Mute) easily controllable by the target audience?					
Will students benefit in social skills from using this package?					

	Unacceptable	Weak	OK	Good	Excellent
Is the voiceover comprehensible?					

Quiz/Reinforcers:

Is the cloze test quiz appropriate for enhancing vocabulary skills?					
Is the matching pairs quiz appropriate for enhancing vocabulary skills?					
Is the sentence maker quiz appropriate for enhancing vocabulary skills?					
Is the choice of vocabulary used within the quiz appropriate for the target audience?					
Do you think there is reasonable progression of difficulty within the quizzes?					
Is the choice of reinforcers motivating?					

	Unacceptable	Weak	OK	Good	Excellent
Is the frequency of the reinforcer suitable?					
Are the navigation buttons navigable by the target audience?					
Is sufficient feedback provided throughout each quiz (i.e. pop up messages)?					

Additional Comments:

What improvements/suggestions can you recommend in relation to this prototype?

_____

_____

_____

_____

_____

What do you like about the prototype?

_____

_____

_____

_____

What do you dislike about the prototype?

_____

_____

_____

_____

Are there any additional features that you would like to see added?

_____

_____

_____

_____

Additional comments?

_____

_____

_____

_____

Thank you for your time

Appendix C: Survey & Statistical Analysis

Online Survey Correspondence

The following sections include the correspondence and online survey used in the national evaluation with special needs tutors.

Letter to School Principal

Dear Principal

I wish to invite a member of your staff to review an online lesson I have developed for learners with autism and then complete a short 15 minute questionnaire, either online or on paper. This masters level, multimedia social story aims to research online instruction for social development.

I would be very grateful for your permission to conduct this research and would ask you to kindly pass the enclosed letter and questionnaire to an appropriate staff member.

If there are any questions or concerns about completing the questionnaire or about being in this study, you may contact me by telephone 087******* or email ltwalsh@wit.ie.

Yours Sincerely,

Leanne Walsh BSc.

Letter to Teachers and Tutors

Leanne Walsh
WeLearnT Research Centre
Luke Wadding Library
Waterford Institute of Technology
Waterford

5th January 2009

Dear Respondent,

I invite you to participate in a research project on the design of multimedia-based instruction to support the academic and social development of children with autism. This research project is funded by The Institutes of Technology Council of Directors, Ireland: Strand 1 Post-Graduate R&D Skills Programme. A computer animated social story has been designed, along with an online vocabulary quiz, to support and enhance the words and phrases used within the social story. The lesson website can be viewed at the following web address: http://www.leannewalsh.com .

Accompanying the website is a short questionnaire on the interface design, lesson and quiz. I am asking you to review the lesson and if you choose, complete the short 15 minute questionnaire. The survey can be found from the web address: http://www.leannewalsh.com by clicking on the link labelled survey at the left hand side of the screen. Optionally a printed copy of the questionnaire is attached to this letter.

The results of this project will be used to assess and document a design framework of computer software for young learners with autism. I hope that the results of the survey will be useful for future development of computer software for young children with special needs. I hope to share my results by publishing them in my Master of Science thesis and at appropriate conferences. I do not know of any risks to you if you decide to participate in this survey and I guarantee that your responses will not be identified with you personally or your school. All survey replies remain confidential; no personal information is requested. I promise not to share any information that identifies you and results will be compiled in anonymous summary format.

I hope you will take the time to complete this questionnaire. Your participation will be much appreciated. Regardless of whether you choose to participate, please let me know if you would like a summary of my findings. To receive a summary, you can contact me via email ltwalsh@wit.ie. The survey will be available online between 7th January 2009 – 30th January 2009.

If you have any questions or concerns about completing the questionnaire or about being in this study, you may contact me by telephone 087******* or email ltwalsh@wit.ie. The Ethics Committee and Postgraduate Board at Waterford Institute of Technology have approved this study.

Yours Sincerely,

Leanne Walsh BSc.
(Research Supervisor Ms. Mary Barry, WIT, mbarry@wit.ie)

Reminder Letter to Teachers and Tutors

Leanne Walsh
WeLearnT Research Centre
Luke Wadding Library
Waterford Institute of Technology
Cork Road
Waterford

23rd January 2009

Dear Respondent,

This is a friendly reminder to take a moment to participate in the evaluation of our online prototype and survey. The goal of this project is to assess and document a design framework of computer software for young learners with autism.

The website can be viewed from the web address: http://www.leannewalsh.com by clicking the link labelled prototype. The online version of the survey can also be viewed by clicking on the survey link, also available at the above mentioned web address. Alternatively, a printed questionnaire can be returned which is available in the original pack.

If you have already participated in our survey prior to receipt of this letter, may I take this opportunity to thank you for your input.

If you have any questions or concerns about completing the questionnaire or about being in this study, you may contact me by telephone 087******* or email ltwalsh@wit.ie. I hope you will take the time to complete this questionnaire. The questionnaire will be available online until the 31st January 2009. Your participation will be much appreciated.

Yours Sincerely,

Leanne Walsh BSc.
(Research Supervisor Ms. Mary Barry, WIT, mbarry@wit.ie)

Survey from SurveyMonkey

1. General Questions on the Prototype Environment

1. How would you rate the effectiveness of colour within the prototype?

	Unacceptable	Weak	OK	Good	Excellent
choose one of the following:	◯	◯	◯	◯	◯

2. How effective are the graphics within the prototype?

	Unacceptable	Weak	OK	Good	Excellent
choose one of the following:	◯	◯	◯	◯	◯

3. How would you rate the suitability of the vocabulary in the prototype for the target audience?

	Unacceptable	Weak	OK	Good	Excellent
choose one of the following:	◯	◯	◯	◯	◯

4. If this prototype was integrated into your class curriculum, how would you rate its suitability?

	Unacceptable	Weak	OK	Good	Excellent
choose one of the following:	◯	◯	◯	◯	◯

5. How would you rate the ease-of-use of the program for the target audience?

	Unacceptable	Weak	OK	Good	Excellent
choose one of the following:	◯	◯	◯	◯	◯

6. How would you rate the effectiveness of the 'HELP' option (purple paw pop-up window) in order to meet users needs?

	Unacceptable	Weak	OK	Good	Excellent
choose one of the following:	◯	◯	◯	◯	◯

7. How navigable is the navigation menu (i.e. Home, Lesson, Quiz Buttons) for the target audience?

	Unacceptable	Weak	OK	Good	Excellent
choose one of the following:	◯	◯	◯	◯	◯

2. Questions on the lesson

1. How legible is the font (Comic Sans) within the lesson?

	Unacceptable	Weak	OK	Good	Excellent
choose one of the following:	◯	◯	◯	◯	◯

2. How appropriate is the font size?

	Unacceptable	Weak	OK	Good	Excellent
choose one of the following:	◯	◯	◯	◯	◯

3. How effective is the synchronization of the voiceover with the colour change on each word within the story?

	Unacceptable	Weak	OK	Good	Excellent
choose one of the following:	◯	◯	◯	◯	◯

4. How controllable by the target audience are the three control buttons (i.e. Play, Stop and Mute)?

	Unacceptable	Weak	OK	Good	Excellent
choose one of the following:	◯	◯	◯	◯	◯

5. How would you rate the benefits in social skills for the students who use this pack?

	Unacceptable	Weak	OK	Good	Excellent
choose one of the following:	◯	◯	◯	◯	◯

6. How comprehensible is the voiceover?

	Unacceptable	Weak	OK	Good	Excellent
choose one of the following:	◯	◯	◯	◯	◯

3. Questions on the quiz

1. How would you rank the suitability of the cloze test quiz for enhancing vocabulary skills?

	Unacceptable	Weak	OK	Good	Excellent
choose one of the following:	◯	◯	◯	◯	◯

2. How would you rank the suitability of the matching pairs quiz for enhancing vocabulary skills?

	Unacceptable	Weak	OK	Good	Excellent
choose one of the following:	◯	◯	◯	◯	◯

3. How would you rank the suitability of the sentence maker quiz for enhancing vocabulary skills?

	Unacceptable	Weak	OK	Good	Excellent
choose one of the following:	◯	◯	◯	◯	◯

4. How would you grade the choice of vocabulary used within the quiz to meet the needs of the target audience?

	Unacceptable	Weak	OK	Good	Excellent
choose one of the following:	◯	◯	◯	◯	◯

5. How would you rate the progression of difficulty within the quizzes?

	Unacceptable	Weak	OK	Good	Excellent
choose one of the following:	◯	◯	◯	◯	◯

6. How navigable are the navigation buttons in the quiz for the target audience?

	Unacceptable	Weak	OK	Good	Excellent
choose one of the following:	◯	◯	◯	◯	◯

7. How would you rate the feedback provided throughout each quiz (i.e. pop-up messages)?

	Unacceptable	Weak	OK	Good	Excellent
choose one of the following:	◯	◯	◯	◯	◯

4. Questions on the reinforcers

1. How would you rate the reward role of reinforcers in the quiz section?

	Unacceptable	Weak	OK	Good	Excellent
choose one of the following:	◯	◯	◯	◯	◯

2. How motivating is the choice of reinforcers (miniature flash games)?

	Unacceptable	Weak	OK	Good	Excellent
choose one of the following:	◯	◯	◯	◯	◯

3. How suitable is the frequency of reinforcers (miniature flash games)?

	Unacceptable	Weak	OK	Good	Excellent
choose one of the following:	◯	◯	◯	◯	◯

Additional Comments

1. What improvements/suggestions can you recommend in relation to the prototype?

_____

_____

_____

_____

_____

2. What do you like about the prototype?

_____

_____

_____

_____

_____

3. What do you dislike about the prototype?

_____

_____

_____

_____

_____

4. Are there additional features that you would like to see added?

_____

_____

_____

_____

_____

5. Have you any further comments?

_____

_____

_____

_____

_____

Many thanks for your time and patience in filling out this questionnaire.

Please return this questionnaire, using the addressed envelope enclosed, to:

Leanne Walsh, WelearnT Research Centre, Luke Wading Library, Waterford Institute of Technology, Cork Road, Waterford.

Statistical Tables[3]

[3] The tables documented in the following section are those not included in the main text

Section A: General questions and results on the prototype environment

Question 1A: Effectiveness of colour

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Weak	1	5.0	5.0	5.0
	ok	4	20.0	20.0	25.0
	Good	8	40.0	40.0	65.0
	Excellent	7	35.0	35.0	100.0
	Total	20	100.0	100.0	

Question 2A: Effectiveness of graphics

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Weak	2	10.0	10.0	10.0
	ok	6	30.0	30.0	40.0
	Good	9	45.0	45.0	85.0
	Excellent	3	15.0	15.0	100.0
	Total	20	100.0	100.0	

Question 3A: Suitability of Vocabulary

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Weak	2	10.0	10.5	10.5
	Ok	6	30.0	31.6	42.1
	Good	9	45.0	47.4	89.5
	Excellent	2	10.0	10.5	100.0
	Total	19	95.0	100.0	
Missing	System	1	5.0		
Total		20	100.0		

Question 4A: Suitability for classroom curriculum

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Unacceptable	1	5.0	5.0	5.0
	Weak	1	5.0	5.0	10.0
	Ok	9	45.0	45.0	55.0
	Good	7	35.0	35.0	90.0
	Excellent	2	10.0	10.0	100.0
	Total	20	100.0	100.0	

Question 5A: Ease of Use of Prototype

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Unacceptable	1	5.0	5.6	5.6
	Weak	4	20.0	22.2	27.8
	Ok	3	15.0	16.7	44.4
	Good	8	40.0	44.4	88.9
	Excellent	2	10.0	11.1	100.0
	Total	18	90.0	100.0	
Missing	System	2	10.0		
Total		20	100.0		

Question 6A: Effectiveness of Help

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Weak	6	30.0	33.3	33.3
	Ok	4	20.0	22.2	55.6
	Good	7	35.0	38.9	94.4
	Excellent	1	5.0	5.6	100.0
	Total	18	90.0	100.0	
Missing	System	2	10.0		
Total		20	100.0		

Section B: General questions and results on the lesson

Question 2B: Appropriateness of Font Size

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Weak	2	10.0	10.0	10.0
	Good	11	55.0	55.0	65.0
	Excellent	7	35.0	35.0	100.0
	Total	20	100.0	100.0	

Question 3B: Effectiveness of Voice-Over

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Ok	5	25.0	26.3	26.3
	Good	9	45.0	47.4	73.7
	Excellent	5	25.0	26.3	100.0
	Total	19	95.0	100.0	
Missing	System	1	5.0		
Total		20	100.0		

Question 4B: Controllability of buttons

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Weak	2	10.0	10.0	10.0
	ok	6	30.0	30.0	40.0
	Good	6	30.0	30.0	70.0
	Excellent	6	30.0	30.0	100.0
	Total	20	100.0	100.0	

Question 5B: Prototype Beneficial for Social Skills

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Weak	2	10.0	10.0	10.0
	ok	4	20.0	20.0	30.0
	Good	8	40.0	40.0	70.0
	Excellent	6	30.0	30.0	100.0
	Total	20	100.0	100.0	

Question 6B: Comprehensible voice-over

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Unacceptable	1	5.0	5.3	5.3
	Weak	2	10.0	10.5	15.8
	Ok	4	20.0	21.1	36.8
	Good	9	45.0	47.4	84.2
	Excellent	3	15.0	15.8	100.0
	Total	19	95.0	100.0	
Missing	System	1	5.0		
Total		20	100.0		

Section C: General questions and results on the quiz

Question 1C: Suitability of Cloze Test

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Unacceptable	2	10.0	10.0	10.0
	Weak	1	5.0	5.0	15.0
	Ok	7	35.0	35.0	50.0
	Good	8	40.0	40.0	90.0
	Excellent	2	10.0	10.0	100.0
	Total	20	100.0	100.0	

Question 2C: Suitability of Matching Pairs

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Unacceptable	1	5.0	5.0	5.0
	Weak	4	20.0	20.0	25.0
	Ok	5	25.0	25.0	50.0
	Good	8	40.0	40.0	90.0
	Excellent	2	10.0	10.0	100.0
	Total	20	100.0	100.0	

Question 3C: Suitability of Sentence Maker

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Unacceptable	1	5.0	5.0	5.0
	Weak	3	15.0	15.0	20.0
	Ok	6	30.0	30.0	50.0
	Good	6	30.0	30.0	80.0
	Excellent	4	20.0	20.0	100.0
	Total	20	100.0	100.0	

Question 4C: Suitability of Choice of Vocabulary

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Unacceptable	1	5.0	5.0	5.0
	Ok	7	35.0	35.0	40.0
	Good	7	35.0	35.0	75.0
	Excellent	5	25.0	25.0	100.0
	Total	20	100.0	100.0	

Question 5C: Rate Progression of Difficulty

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Weak	3	15.0	15.0	15.0
	Ok	5	25.0	25.0	40.0
	Good	10	50.0	50.0	90.0
	Excellent	2	10.0	10.0	100.0
	Total	20	100.0	100.0	

Question 6C: Navigable are Nav Buttons

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Unacceptable	1	5.0	5.0	5.0
	Ok	8	40.0	40.0	45.0
	Good	8	40.0	40.0	85.0
	Excellent	3	15.0	15.0	100.0
	Total	20	100.0	100.0	

Question 7C: Effectiveness of Feedback (pop messages)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Unacceptable	1	5.0	5.0	5.0
	Weak	1	5.0	5.0	10.0
	Ok	10	50.0	50.0	60.0
	Good	5	25.0	25.0	85.0
	Excellent	3	15.0	15.0	100.0
	Total	20	100.0	100.0	

Section D: General questions and results on the reinforcers

Question 1D: Rate of Reward Role

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Unacceptable	1	5.0	5.3	5.3
	Weak	3	15.0	15.8	21.1
	Ok	7	35.0	36.8	57.9
	Good	6	30.0	31.6	89.5
	Excellent	2	10.0	10.5	100.0
	Total	19	95.0	100.0	
Missing	System	1	5.0		
Total		20	100.0		

Question 3D: Suitability of Frequency of reinforcers

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Weak	3	15.0	15.8	15.8
	Ok	8	40.0	42.1	57.9
	Good	7	35.0	36.8	94.7
	Excellent	1	5.0	5.3	100.0
	Total	19	95.0	100.0	
Missing	System	1	5.0		
Total		20	100.0		

Appendix D: Publications

Short Paper at IADIS International IHCI Conference 2008

DEMYSTIFYING THE INTERFACE FOR YOUNG LEARNERS WITH AUTISM

ABSTRACT

This study illustrates a design framework for a social routine instructional prototype for young learners with autism.

Requirements and user profile data were previously gathered from an Applied Behavior Analysis (ABA) school. Software currently available for young learners with cognitive impairments and web accessibility guidelines have been reviewed.

The early design phases of the usability engineering lifecycle are documented, to construct initial design sketches of the software and social routine lesson interface. Image editing software is used to create a graphical representation of the design sketches. The paper prototypes are evaluated by tutors in the ABA school. Comparisons are made between different prototypes, and recommendations for further design and development are established.

We conclude that colour and animation should be minimized, and an individual windowed interface should represent the main navigational display of the prototype. A customizable option for colour, font type and font size should be integrated to accommodate for the specific needs of individual learners with cognitive impairments. Multi-modal input such as a touch screen, switch and mouse should be incorporated into the design. A further computer-based implementation is recommended to provide for an additional investigation into the needs of the learner.

KEYWORDS

Autism, Cognitive Impairment, Interface Design, Human Computer Interaction, Animation, Usability Engineering.

Reference:

Walsh, L. & Barry, M., (2008) Demystifying the Interface for Young Learners with Autism. *In Proceedings of IADIS International Conference IHCI 2008, part of MCCSIS 2008*. (pp. 308-313). Amsterdam, Netherlands: IADIS.

Poster Presentation at ALT-C 2008

A Multimedia Instruction to Enhance the Social Skills of the Young Learner with Autism

ABSTRACT:

This study researches the social development of young learners with autism in order to develop a multimedia-based social instructional program. The main feature incorporated within the software is the implementation of social routines as an eLearning virtual environment. Social stories teach social skills to children with autism. They prepare the child's understanding for upcoming events by highlighting key points of the event. Social stories are a successful educational tool currently used via videotape and paper-based means. This body of work is an original approach involving the creation of routines/stories through a computer animation.

This project focuses on researching social development of learners with autism in order to develop a multimedia-based instructional software program. A fully functional multimedia based prototype is currently being developed which will provide an educational environment to assist in the social development of the young learner with Autistic Spectrum Disorder (ASD). The software will adopt and seek to improve upon the framework of standards set out by the W3C Web Accessibility Initiative. The software design is strictly "*human – centred"* in that the learners with autism in local schools are included in the design process.

During requirements analysis phase of the usability lifecycle children with autism in the four to nine year range are observed using educational software in their school environment. Any problems, trends or preferences in software usability are recorded. All collaborations and fieldwork will be completed on a local level with a possibility of expanding the multimedia technology to a global internet-based audience. Through a combination of the pedagogical requirements of the learners and assessments made through observations, a user profile is created which provides a framework for the design of the educational technology.

A user-centred design approach is implemented throughout this software development. Young learners and their tutors are included throughout the design process. Teachers are employed as collaborators on the project, to obtain their insight into the usability and effectiveness of educational software on learning. Initial collaborations with teachers have involved benchmarking of software currently available. Design advice has been merged with standard HCI principles in the building of initial storyboards, to provide for the learner with special needs.

This account provides a synopsis of the current body of work and future implementations in the design of the multimedia instructional software. The user-profile is being explored in order to create an educational framework for the learner with special needs. Further phases will assess usability guidelines and principles such as the Web Accessibility Initiative (WAI) in order to cater for the accessibility needs of the learner.

Reference:

Walsh, L. & Barry, M., (2008) A Multimedia Instruction to Enhance the Social Skills of the Young Learner with Autism. *In Proceedings of ALT-C 2008: Re-thinking the Digital Divide*. Leeds, UK: Association for Learning Technology.

Short Paper at iHCI Conference 2008

A Visual Narrative for Teaching Social Routines: Animations for Young Learners with Autism

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ABSTRACT

This study investigates the design structure of an online social educational program, for young learners with autism. Prior investigations of learner requirements and child/user roles have provided a representation of the user profile for the child learner with special needs. Online lesson interfaces are evaluated by tutors in special needs schools. Social skill story themes have been decided upon and implemented into animated online lessons. The accompaniment of computer-based vocabulary and word-based quizzes, adopts the Discrete Trial Instruction (DTI) method of learning reinforcement. This may lead to added retention of information and increased improvement in the transfer of knowledge. It is concluded that further computer-based implementation of reinforcers, such as the inclusion of flash games and audio, should be incorporated to motivate learning.

Reference:

Walsh, L. & Barry, M., (2008) A Visual Narrative for Teaching Social Routines: Animations for Young Learners with Autism. *In Proceedings of Irish Human Computer - Interaction Conference 2008.* (pp. 139-141). Cork, Ireland: I-HCI.

Short Paper at m-ICTE Conference 2009

An investigation of computer animated reinforcers as a motivational tool for children with autism

L. Walsh[1] and M. Barry[1]

[1] WelearnT Research Centre, Department of Computing, Mathematics and Physics, Waterford Institute of Technology, Waterford, Ireland.

ABSTRACT

This research project incorporates the design and development of a social scenario software prototype for young learners with autism. A multimedia social skills story has been developed as a computer-based learning tool. A series of quizzes have also been created as an accompaniment to aid in the knowledge transfer and reinforcement of significant points within the social skills lesson. Collaborations are ongoing with tutors and children in local special needs schools, to allow for regular input and testing of the prototype.

Motivation and positive feedback are important elements of the learning process to engage a learner's attention, especially in the case of young learners with autism. The Discrete Trial Instruction framework incorporates both these features through a process known as reinforcement, to reward or encourage a new skill learnt or good behaviour demonstrated by a young learner with autism. This paper discusses the investigation of reinforcers enjoyed by these young learners, and how reinforcers can be transformed into a computer-based format.

The researcher conducted early investigations in local schools with special needs units in the area. Interviews were also completed with parents of young learners with autism to examine the children's preferred means of reinforcement. Findings suggest that reinforcers are dependent upon each individual child's preferences. The range of reinforcers varied from sweets to toys and computer games. They also enjoy watching scrolling text on a screen and some children like to skip to the end of movies and television programmes to view the flowing text. On evaluation of these findings the researcher investigated ways of incorporating each element into computer-based reinforcers as a means of rewarding the learners at the end of a quiz.

Sound and movement were agreed upon as the key components to include within each animated reinforcer. Previous research states that children's motivations were increased upon receipt of a game at the end of each lesson. It was therefore decided to have a selection of different animations available at the end of each quiz which the learner could select. A total of six reinforcers were created for inclusion within this project. The reinforcers are provided randomly throughout the program to support anticipation and surprise. Since the child does not know when to expect the reward, variable timing encourages the child to work harder to receive the reward. A timer is also integrated into the game, which switches off the game and directs the child back to the lesson after a set period of time. Evaluations within the Irish primary school sector have allowed for valuable insights and feedback on the effectiveness of this software design approach.

Findings should contribute to more specific guidelines for multimedia software development for children with autism.

Keywords Autism; Discrete Trial Instruction; Reinforcer; Multimedia; HCI; Animation

Reference:

Walsh, L. & Barry, M., (2009) An investigation of computer animated reinforcers as a motivational tool for young learners with Autism. *In Proceedings of V International Conference on Multimedia and ICT in Education*. (pp. 1251-1254), Lisbon, Portugal: m:ICTE.

Short Paper at Edtech Conference 2009

A Classroom Investigation of Software Design Requirements for Special Needs Learners

L. Walsh[1] and M. Barry[1]

[1] WeLearnT Research Centre, Department of Computing, Mathematics and Physics, Waterford Institute of Technology, Waterford, Ireland.
Paper type: Postgraduate

ABSTRACT:

Our study investigates the establishment of a design framework for multimedia software design for young learners with autism. The researcher, in partnership with local special needs and autism schools, has developed a social skills multimedia-based lesson. The Discrete Trial Instruction (DTI) teaching approach has been adopted within the framework of the prototype. DTI is a teaching method used to teach children with learning difficulties. DTI aims to positively improve a social behaviour or teach a task to a child within the classroom environment. The researcher has completed an in-depth study in the field in order to build a specific user model for these young learners. A series of interviews, classroom observations, parent/tutor reviews and sequential prototype design evaluations have been performed. Non-obtrusive observation techniques have been followed throughout the user profile building stage, as suggested by Druin, a children's technology and interaction design expert. This approach enables learners to feel at ease in their own environment.

Findings from these early investigations and user profiling have shown that ease of access to technology and software is a key criterion for these young users. A variety of multimodal technologies such as touch screens and switches must also be integrated into the design of software. These technologies alleviate the motor and input difficulties which many young learners find when using the more common hardware devices such as a keyboard or mouse.

Further recommendations have also indicated the importance of audio to be included within the prototype construction. From the perspective of this project, voice-overs have been recorded to assist children with reading and understanding of lesson content. Results from initial evaluations state that current software on the market is strongly targeted at an American audience. Our project consists of an Irish tone in order to make the lesson more comprehensible for the young learner. In accordance with the DTI approach an animated social scenario lesson has been created using web animation tools. Accompanying the animation is a sample quiz and short animated rewards to assist with motivation and the transfer of knowledge of the lesson content.

A nationwide survey is currently in progress to further consolidate the design structure of the prototype. A random sample of Irish national special needs schools has been chosen to participate in the survey. An online questionnaire documenting both interface design and software usability questions has been developed to evaluate the software design framework. It is anticipated that results from this survey should further help the progression of educational computer-based programs for young learners with autism,

and contribute to a clearer understanding of multimedia and software development approaches that have good learning and teaching potential.

Keywords Learners with Autism; Social Skills; Usability; Storyboarding; Multimedia; Animation

Reference:

Walsh, L. & Barry, M., (2009) A Classroom Investigation of Software Design Requirements for Special Needs Learners. *In Proceedings of Edtech Conference.* Dublin, Ireland