Developing Educational Games for Teaching Children with ASC

Peter's Adventures: A tablet app to elicit pretend play for Children with ASC

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ABSTRACT

For children with autism spectrum condition (ASC), initiating pretend play in early childhood can be unnatural to them as they suffer from developmental delays in symbolic and divergent thinking. Pretend play is the substitution of imaginary situation that satisfies the child's personal wishes and needs within his/her make-belief scenarios or stories. Subsequently, pretend play has been found to be closely associated with a child's cognitive, language and social development. As augmented reality (AR) systems are able to visually conceptualise the representation of pretence within an open-ended environment, this study aims to develop an effective educational tool that can enhance the initial steps a child with ASC takes into pretend play by designing a story-based AR tablet game. A Participatory Design approach consisting of typically developing children and experts was used to design, develop and evaluate the app. The results indicate that the game can be used as an educational aid to support pretend play in children with ASC.

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I would like to thank Dr Helen Pain for her immense support, expertise and guidance throughout the project. Without her, I would have absolutely no clue on what to do.

Also, I would like to thank the children, Ms Vanessa Zervogianni, Ms Mihaela Drogomir and Dr Kami Vanaiea for their very useful feedback and great ideas throughout the game development.

I would also like to thank my parents, special friends and cookies for their unconditional support throughout my years as an undergraduate.

DECLARATION

I declare that this thesis was composed by myself, that the work contained herein is my own except where explicitly stated otherwise in the text, and that this work has not been submitted for any other degree or professional qualification except as specified.

Orisa Ngampakdeepanich

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CHAPTER 1

INTRODUCTION

1.1 PRETEND PLAY IN CHILDREN WITH ASC

Westby (1991) observed that pretend play influenced every faucets of development and helped healthy growth of emotion, convergent and divergent thinking, language literacy, impulse control, perspective taking and socialisation. When a child is involved in pretend play, he is suspending or transcending reality to allow room for imagination and creativity to flow. Pretend play, also known as 'symbolic' or 'make-believe' play, refers to substituting a situation with another imaginary situation to satisfy one's personal needs and wishes for fun (Smilansky, 1968). To facilitate pretend play, a child would create a narrative or tell stories to serve the purpose of pretence (Mallan, 1998). This requires sequencing and organisation of thought and initialisation of play ideas (Westby, 1991).

Children with ASC, however, do no not naturally engage in or initiate pretend play because they have difficulties in giving dual identity to an object such that the appearance of the object does not alter its original identity or vice versa, i.e. a lollipop moulded into a shape of a foot will be identified by a child with ASC as only a lollipop or only as a foot (Baron-Cohen, 1989). This impairment to interpret meta-representational objects exacerbates the autistic children's poor ability to spontaneously produce pretend play (Frith & Leslie, 1988) as seen from many studies reporting that pretend play is less frequently found in children with ASC (Baron-Cohen, 1987) (Lewis & Boucher, 1988) (Wing, et al, 1977). Thus, according to the 10th revision of the International Statistical Classification of Diseases and Related Health Problems, (ICD-10), impaired ability of the child to execute functional or symbolic play before the age of 3 years is an indicator of childhood autism (World Health Organisation, 1993).

Subsequently, it was proposed that AR can be used as an external structure to help children with ASC understand the mechanism of symbolic thought (Bai, 2014). By enabling the children to learn the representational and transformation nature of symbolic thought through visual stimulus, AR can hence, be an effective learning tool. As children with ASC tend to visual learning style, this approach can help them to overcome the learning obstacles caused by their difficulties with language (Quill, 1997). Furthermore, AR allows children to physically manipulate an otherwise, invisible imaginary representation object. This encourages them to practice related play ideas and generate symbolic transformations (Bai, 2014).

This research investigates how a story-based AR game tablet app can support and enhance the development of pretend play in children with ASC. The application is addressed to children who are new to pretend play and thus, possess the cognitive skills in the area of a 3-4 year old typically developing child (Saracho & Spodek, 1998). The application will aim to be supportive of the child's independent playing and learning. Ultimately, the beneficiaries of the research will be the children with ASC, their guardians or parents, and education professionals who teach these children.

The following summarise the work undertaken for this dissertation:

1. Activities conducted to inform the design of the developed application through observations, measurements, interviews and researching design principles.

2. Development of an Andriod application (on a Samsung Galaxy tablet) to encourage and elicit pretend play for children with ASC.

3. Repeated testing of the design, including prototyping, usability studies, surveys and evaluations with academic experts and typically developing children.

1.2 Research Objectives

This research investigates how to design an AR tablet game app which encourages pretend play in children with ASC. Thus the study aims to answer the following questions:

1. Is the AR game appropriate for children with ASC?
2. Will the target group in general find the AR game fun and engaging?
3. Will the AR game be effective in encouraging and supporting pretend play behaviours in children with ASC?

1.3 Structure of Dissertation

The remainder of this dissertation is structured as follows:

Chapter 2: The chapter presents a literature review that forms the background of this research and directs the consequent research development via the subsequent discussion of research question and methodology used.

Chapter 3: The chapter describes the observations of young children during design workshops as the pre-design stage of the research.

Chapter 4: The chapter describes the design stage including design guidelines, requirements, structure and justifications for decisions made. Semi-structured interviews with experts and pilot testing which updated the design decisions are also discussed.

Chapter 5: The chapter presents the evaluation of the application with young children and experts.

Chapter 6: The chapter concludes the dissertation, discussion the evaluation stage's results and potential further work to be carried out.

Chapter 2

Literature Review

To facilitate game design, we need to specify the purpose of the game, honing down on the specific difficulties children with ASC have with pretend play, and how we can potentially alleviate the problem. Thus, this chapter describes children with ASC (especially their characteristics which might or will affect their game play experience), what exactly is pretend play and its benefits for children with ASC, existing methods used to elicit pretend play for children with ASC and how children with ASC interact with stories, digital game applications and augmented reality technology. Lastly, the methodology used in this research is discussed.

2.1 Autism

Affecting about 1% of the UK population (Baron-Cohen, et al., 2009), autism is a pervasive neurodevelopmental disorder characterised by a significant impairment to a child's social interaction, communication, play and imagination skills (Levy, et al, 2009). Autism is a spectrum disorder which means that it entails a range of connected conditions and occasionally extends to include singular traits and symptoms. These varied conditions are assumed to be caused by the same underlying mechanism (Maser & Akiskal, 2002). The differences in how being autistic affect the person and how he/she was diagnosed resulted in varied terms used to diagnose autistic patients. In this study, the term "Autism Spectrum Condition" (ASC) will often be used to define the range of autism spectrum.

2.1.1 Characteristics of Children with ASC

From the ASC guidelines in the Diagnostic and Statistical Manual of Mental Disorders, 5th edition (DSM-5), there are four criteria used to diagnose an individual with ASC. In the first criteria, the symptoms mainly affect social interaction and communication over various contexts such as difficulties in social initiation and response, non-verbal communication, social awareness and insight (American Psychiatric Association, 2013). For example, when spoken to, a child with ASC may fail to respond altogether either due to a lack of interest or acknowledgement of the person speaking. Moreover, when not understood, a child with ASC would not try to clarify himself/herself or provide contextual information due to the difficulty of mastering pragmatic/social use of language (American Psychiatric Association, 2013). He/she would tend to keep to himself/herself, not sharing interests or emotions with others. Thus, left on their own, children with ASC tend to have very little to no social interaction with the people around them.

One of the main factors affecting an autistic child's ability to respond appropriately in social situations and be socially aware is his/her lack of **"theory of mind"** (Baron-Cohen, et al, 1985). Having "theory of mind" is the ability to infer mental states such as beliefs, desires, intentions, imaginations and emotions of oneself and others that then result in subsequent actions (Baron-Cohen, 2001). Hence, it means being able to empathise and be aware of what is inside one's own and other's minds. In an experiment aimed to test the children's ability to distinguish between mental and physical experience, it was found that children with ASC have

significantly more difficulty than children without ASC (3-4 year-old) at making the right ontological judgement (Baron-Cohen, 1989) (Wellman & Estes, 1986). Children with ASC would not be able to tell the difference between a character thinking of a dog and a character holding a dog, incorrectly assuming that the dog being thought of is tangible. This lack of physical and mental distinction contributes to their inability to put themselves in others' shoes and judge what others may be thinking (Baron-Cohen, et al, 1985). This hampers a child's social interaction as his/her emotional experience and thinking experience from a non-literal interaction would be vastly different to that of his/her non-affected peers.

Moreover, children with ASC are unable to give dual identity to an object such that the appearance of the object does not alter its original identity or vice versa, i.e. a lollipop moulded into a shape of a foot will be identified by a child with ASC as only a lollipop or only as a foot (Baron-Cohen, 1989). On the other hand, children with no ASC (aged about 4 years old) are found to be able to distinguish between reality and appearance so that they are able to explain that the lollipop is shaped to look like a foot but is still essentially a lollipop (Flavell J. H., 1986). This impairment to interpret meta-representational objects exacerbates the autistic children's poor ability to spontaneously produce pretend play (Frith & Leslie, 1988) as seen from many studies reporting that pretend play is less frequently found in children with ASC (Baron-Cohen, 1987) (Lewis & Boucher, 1988) (Wing, et al, 1977). Thus, according to the 10th revision of the International Statistical Classification of Diseases and Related Health Problems, (ICD-10), impaired ability of the child to execute functional or symbolic play before the age of 3 years is an indicator of childhood autism (World Health Organisation, 1993). Further discussion on pretend play will be covered in section 2.2 of the review.

Another cause for social communication difficulties in children with ASC may be their joint (shared) attention problem. Joint attention is the shared focus between two persons and an object via eye-gazing (used exclusively for narrower definition), pointing, or other verbal or non-verbal expression (Moore & Dunham, 1995). From the gaze-direction of a person, children (approximately 4 years old or older) can infer when the subject is thinking (i.e. gaze directed upwards or at nothing particularly (Baron-Cohen & Cross, 1992)) and which objects the subject wants, is interested in or is referring to (Butterworth & Jarret, 1991). However, children with ASC are unable to naturally interpret the mentalistic implication of the eyes of another person even when they can acknowledge what that person is looking at (Baron-Cohen, et al, 1997) (Baron-Cohen, 2001). This may lead to difficulties in social-emotional reciprocity (American Psychiatric Association, 2013) wherein a person is able to influence and be influenced by the behaviour of another person.

In the second criteria of DSM-5, a few more symptoms of ASC were described such as uncommon movements, preoccupations with objects or topics, rituals and inflexibility to change, and uncommon sensory behaviours (American Psychiatric Association, 2013). Although many studies assume that the inflexible daily behaviours in autism correspond to cognitive flexibility deficits, it is not clear that the mechanistic models used to measure the flexibility deficits are accurate (Geurts, et al, 2009).

2.1.2 Impact of Intervention on Children with ASC

Although autism is a serious neurological disorder, the developing brain is very malleable and open to learning. As the symptoms are present in early childhood (approximately children of age 8 or younger), the condition may not be permanent for the child with ASC if necessary interventions are enforced early on once detected (American Psychiatric Association, 2013). Adaptive behaviours such as their communication skills, social skills or imaginative behaviours, may improve over time while their problematic behaviour such as aggression towards others or self-harm may be reduced.

There have been several successful behavioural intervention programmes which aim at alleviating the symptoms such as the Early Intensive Behavioural Intervention (EIBI). The effectiveness of EIBI was demonstrated in an applied behaviour analysis where the quality of 11 studies with 344 children (aged 10 and younger) with ASC were assessed. Compared to the control group, the analysis showed that the groups that has gone through EIBI performed significantly better on IQ, non-verbal IQ, expressive and receptive language and adaptive behaviour (Peters-Scheffer, et al, 2011). Hence, this implies that autistic-related behaviours are not permanent and can effectively be alleviated through intervention programmes, improving the children's quality of life indefinitely.

Another study has also shown the long-term effectiveness of intervention programmes such as the Early Start Denver Model (ESDM) on children aged 18 to 30 months. Upon receiving the intensive treatment for 2 years, there was an improvement in core autism symptoms 2 years later along with gains in IQ, adaptive behaviour, symptom severity and challenging behaviour during the treatment (Estes, et al., 2015). Thus, treatments can be sustainable and effective over a period of time for developing children with ASC.

2.2 Pretend Play

When a child is involved in pretend play, he is suspending or transcending reality to allow room for imagination and creativity to flow. Pretend play, also known as 'symbolic' or 'make-believe' play, refers to substituting a situation with another imaginary situation to satisfy one's personal needs and wishes for fun (Smilansky, 1968). The 'imaginary situation' can be object substitution (i.e. pretending a red ball is a meatball), attribution of properties not present in an object (i.e. pretending bullets are being shot from a toy gun) or conjuring of an imaginary object (i.e. feeding an imaginary rabbit) (Leslie, 1987). The difference between pretend play and other forms of play is that it is nonliteral and thus, depends on dual representations of pretence and reality. Based on a Piagetian model, spontaneous pretend play happens when a child is in between the age of 18 months to 6 years with age 3-5 being the peak of pretend play (Piaget, 1962). The emphasis on 'spontaneous' pertains from the need to distinguish between imitated pretend play and non-guided pretend play. Studies have been made to encourage pretend play in children with ASC where pretence was allowed to be imitated from the experimenter, however, it can be argued that imitation is not the same as initiation of pretend play as there is no novelty involved in the process (Jarrold, et al, 1996) (Bergen, 2002) (Luckett, et al, 2007). Hence, spontaneous pretend play is prioritised over pretend play.

2.2.1 Learning Pretend Play

From the age of 18 to 30 months, typical developing children would learn how to pretend play with the help of their caretakers (i.e. their mothers). There are five stages proposed by Elena Bugrimenko and Elena Smirnova (1994) which occur during the development of object substitution skills when a child engages in pretend play (Saracho & Spodek, 1998).

1. The first stage occurs when the children (aged 18 months) would play with realistic toys and show no interest in object substitutions being performed by adults.
2. The second stage occurs when the children imitate adult-initiated object substitutions but do not understand that one object is being substituted for another.
3. The third stage occurs when the children independently imitate object substitutions performed by an adult earlier.
4. The fourth stage occurs when the children are able to initiate their own object substitutions but are unable to rename the objects with substitute names.
5. The last stage occurs when the children (about 3 year-old) are finally able to initiate and rename substitute objects.

From the stages, we can see that children with ASC will have difficulty at stage 2 whereby they would not be able to understand that one object is being represented by another. Stage 3 to 5 are reliant on this realisation. The skill required for a child to engage in pretend play is the ability to decentralise objects, himself/herself or others, and situations while simultaneously understanding their original identities (Stagnitti & Unsworth, 2000). According to Jean Piaget's theory of cognitive development, decentration means the stage of development where a child withdraws from an egocentric world to a world shared with other people (Piaget, 1962). This capacity allows the child to be engaged in play directed towards other children or objects (Rubin, et al, 1983).

At the core of these limitations, children with ASC are unable to have many perspectives of a single concept. Thus, to tackle the obstacle preventing children with ASC from initiating pretend play, we will need to help them realise the possibility of objects having dual identities. Researcher Zhen Bai from the University of Cambridge has noticed that children with ASC tend to be visual thinkers (Collins, 2013). Thus, she has lead studies utilising augmented reality (AR) technology to externalise the mental image of pretence in the children's immediate environment to aid them picking up the concept of imaginative play. Her researches will be further discussed in section 2.3 of the literature review.

2.2.2 Benefits of Pretend Play

A model of pretend play, Figure 1, is put forward to show the capacities needed for a child to pretend play and how pretend play in return, also further develops the child's cognitive, social, emotional and sensorimotor skills[1] (Stagnitti & Unsworth, 2000). It can be seen that the whole cycle is a positive feedback loop where the developmental capacities of the child serves his pretend play activity and vice versa. Westby (1991) observed that pretend play influenced every faucets of development and helped healthy growth of emotion, convergent

[1] Sensorimotor skill is the ability of a child to manipulate and explore objects during play.

and divergent thinking, language literacy, impulse control, perspective taking and socialisation.

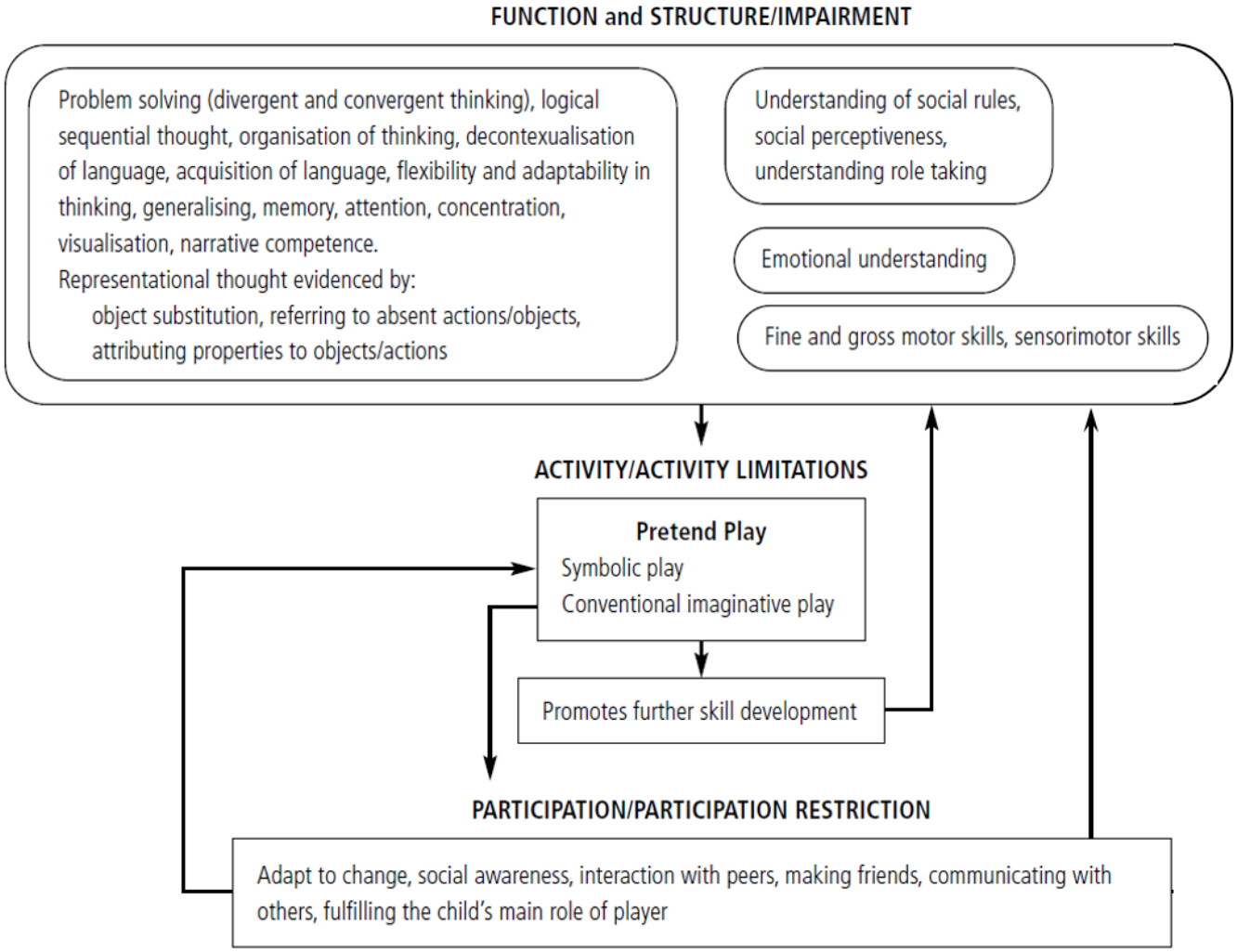

FIGURE 1. A MODEL OF PRETEND PLAY BASED ON WORLD HEALTH ORGANISATION'S (WHO) CLASSIFICATION SYSTEM (STAGNITTI & UNSWORTH, 2000)

By envisioning being in a situation one has never been in before (i.e. flying a space ship), children engaged in pretend play were found to be better at divergent problem-solving tasks than the control group (Wyver & Spence, 1995). During pretend play, a child would create a narrative or tell stories to serve the purpose of pretence (Mallan, 1998). This requires sequencing and organisation of thought and initialisation of play ideas (Westby, 1991). Thus, narrative competence, organisation of thinking, decontextualized language ability and expressing thoughts in writing are pre-literacy cognitive skills found to have an influence on pretend play (Schrader, 1990) (Pelligrini, 1993).

In addition, because children often involve other children in their play of pretence, social awareness is developed. From their own experiences with social rules, children would become aware of the society's behavioural norms and rules. These lessons would then be reflected during their pretend play, i.e. playing being secretaries reflects the rules of professional behaviour (Vygotsky, 1966). By being able to pretend being in situations with differing outcomes to reality, the children would then be able to improve their capacity to

decentre from the self (Rubin, et al, 1983). This mental process leads to an increased capacity to empathise and understand others' perspectives (Baron-Cohen, 1996).

2.2.3 Other Types of Play

To be able to measure pretend play, we have to be able to distinguish it from other types of play during a play observation session. Building on Piaget's developmental stages of play, which are the practice stage, the symbolic stage and the rule-based stage, Smilanskey classified play into functional, constructive, dramatic and rule-based play (Piaget, 1962) (Smilansky, 1968). To formalise the findings, the Play Observation Scale (POS)[2] was designed, proposing four main types of play coding (other than pretend play) (Rubin K. H., 1989):

1. **Functional play**
   This type of play involves the child engaging in simple motor activities with or without objects such as climbing on to a table, dancing for non-dramatic reasons or making faces.

2. **Constructive play**
   This type of play involves the child manipulating objects in order to construct or create something. This is different from functional play as it involves having a goal during play. For example, the child may be shaping playdough to form a bear, filling up a container to make a pool or piling leaves to make a hut.

3. **Exploration**
   This type of play involves the child being fixated on an object in order to obtain sensory information (visual/auditory etc.) about its particular physical properties. For example, the child may be examining a seashell in his/her hand or listening to/for a noise.

4. **Games-with-Rules**
   This type of play occurs when prearranged rules are accepted by the child, influencing his/her play behaviour as he/she adapts to them and controls his/her actions and reactions within the given threshold. An element of competition is involved against other children or against oneself within the play, hence, the term 'game'. For example, the child may be trying to score more tennis balls into a basket than others or competing with others to see who can jump the furthest from the swing without landing into the puddle of water.

Other than pretend play, the coding scheme most commonly utilised in autism research involves functional play, relational play and simple manipulation/sensorimotor play (Bai, et al, 2015). Unlike constructive play, relational play refers to the child manipulating object(s) in relation to other objects without the intent of constructing something i.e. arranging balls together arbitrarily. Meanwhile, simple manipulation/sensorimotor play refers to the child

[2] A standardised guideline used to analyse a child's play behaviour

simply manipulating object with no intents or purposes i.e. waving, banging, and throwing an object.

2.3.4 AR and Pretend Play

It was proposed that AR can be used as an external structure to:

1. Help children with ASC understand the mechanism of symbolic thought (Bai, 2014).

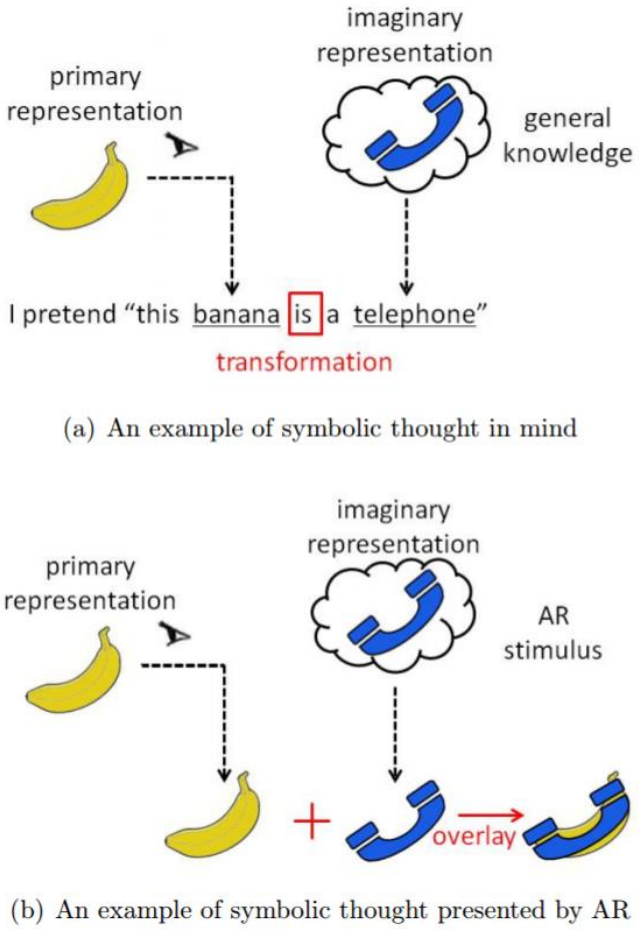

FIGURE 2. EXAMPLES OF SYMBOLIC THOUGHTS BEING REPRESENTED (BAI, 2014)

As shown in Figure 2(a), symbolic thought is formed when a child sees a banana in front of him as the primary representation and then, based on his/her general knowledge in his/her "central cognitive systems", the child's mind then conceived an imaginary representation of a telephone (Bai, 2014). Hence, the banana when through a 'transformation' to become a telephone, resulting in the symbolic thought "this banana is a telephone". On the other hand, Figure 2(b) shows how the AR represents the same symbolic thought by providing a visual stimulus in place of an imaginary representation from the child's general knowledge. Thus, AR externalises the process of symbolic thought by superimposing the image of the telephone on the mental image of the real banana. As mentioned earlier, most children with ASC has delayed development in their metarepresentation ability and thus, they rarely engage in

pretend play. By enabling the children to learn the representational and transformation nature of symbolic thought through visual stimulus, AR can hence, be an effective learning tool. As children with ASC tend to visual learning style, this approach helps to overcome the obstacles caused by their difficulties with language (Quill, 1997).

Furthermore, AR allows children to physically manipulate an otherwise, invisible imaginary representation object. This encourages them to practice related play ideas and generate symbolic transformations. This is further supported by a research which concluded that physical manipulation is essential to accelerate children's development of representation and social cognition (Flavell J. H., 1990). Also, physical manipulation encourages appreciation of symbols in pretence (Lillard, et al, 2011).

2. Reinforce divergent thinking and theory of mind during play (Bai, 2014).
   Symbolic thought (represented by the AR system) is the foundation of divergent thinking and theory of mind cognitive processes (Bai, 2014). Also, an AR system can initialise the visualisation of imagery representations to help children generate open ended play ideas without following explicit instructions (physical or verbal) as such instructions can limit the children's spontaneity and novelty in symbolic play (Bai, 2014).

2.3.5 Related Work and Further Studies

2.3.5.1 Main Research

A recent research has researched eliciting pretend play in children with ASC using augmented reality (AR) technology. The idea is to integrate virtual contents with reality to bridge the gap between the symbolic and nonliteral worlds. As seen from Figure 3, the experimenters built an AR system which consisted of marked wooden blocks and a big screen before the play table. The screen displays the player together with the augmented objects, acting as a mirror with the augmentations.

After a series of evaluations, it was found that in certain cases, AR could support the mental representation of pretence by augmenting imaginary alternatives of the marked blocks (Bai, et al, 2015). The effectiveness of their system was correlated to the degree of developmental delay the children with ASC have in pretend play; the more severe the deficit, the more effect it has on the child. For the children with ASC who are already comfortable with pretend play, it was suggested that the salient visual effect may encourage them to adapt to new themes outside of their comfort zones (Bai, et al, 2015). Overall, the experiment results confirm an increase in the frequency of pretend play behaviour, an increase in pretend play duration and an increase in consistency of play ideas to suggested theme (Bai, et al, 2015).

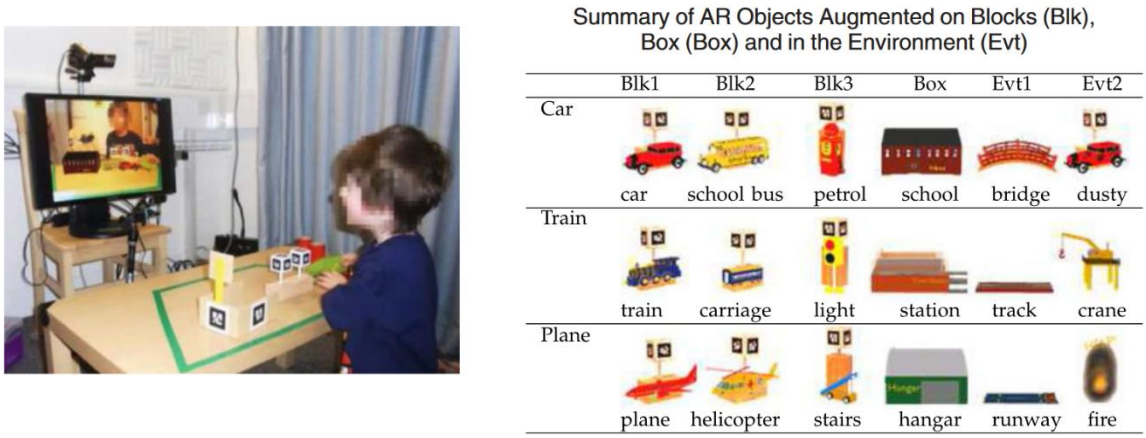

FIGURE 3. SYSTEM SETUP WITH USER AND SUMMARY OF AR OBJECTS AGUMENTED (BAI, BLACKWELL, & COULOURIS, 2015)

2.3.5.2 FingAR Puppet

Subsequently, the same researchers went on to create FingAR Puppet which is an AR system aimed at helping general children link expressive interpretations with immediate reality to encourage social pretend play (Bai, et al, 2015a). The experiment succeeded in encouraging the children to generate a variety of symbolic transformations through open-ended representations whereby the augmented puppets were allowed to have many kinds of facial emotions.

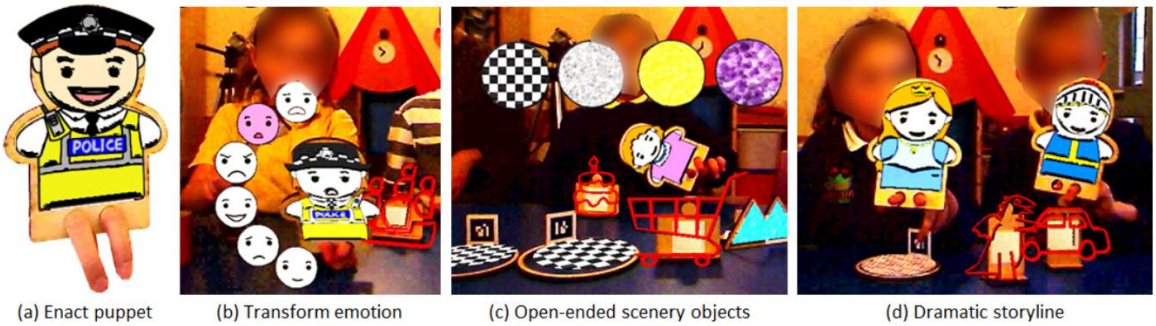

FIGURE 4. OVERVIEW OF THE FINGAR PUPPET PLAY SYSTEM

When dealing with children with ASC as participants of the AR system experiments, experimenters found that it was challenging to persuade a child to take part in activities that he/she is not interested in (Bai, et al, 2015). Thus, it is important that the system is appealing enough to children with ASC for any period by giving them a selection of different AR objects with different shape, colour, etc. (Bai, et al, 2015).

Another study has shown that for children with ASC to be truly motivated via intrinsic means to pretend play, it has to be fun, creative and spontaneous as opposed to be merely prompts directed (Kasari, et al, 2013). In an experiment which applied rating of "playfulness"[3] to

[3] A measure consisting of self-awareness, creativity in play and fun as expressed by positive affect and pleasure. (Hobson, Hobson, Malik, Bargiota, & Calo, 2013)

children's pretend play acts in a normalised assessment of play skills, it was discovered that children with ASC would perform the "mechanics" of play similar to the controls but were less invested in "playful pretence" (Hobson, et al, 2013). Hence, to motivate intrinsic pretend play in children with ASC, we will try to make the play process fun by integrating the AR technology into a game environment.

2.3.5.3 pOwerball

An example of play-centred strategy would be pOwerball, a unique tabletop tangible AR flipper game that encourages social interactions between children with and without a physical or learning disability (Figure 5).

FIGURE 5. GAME BEING PLAYED DURING EVALUATION STAGE (BREDERODE, MARKOPOULOS, GIELEN, VERMEEREN, & RIDDLER, 2000)

Before the implementation of the game, the researchers conducted observations and interviews with children (aged 8-14, with and without disability) to conclude design goals. Two of them being:

A. Fun
   The game should have a clear and simple goal, altering between being constructive and competitive during play. Having variation, letting the children try out and discover new things also adds to the fun factor. (Brederode, et al., 2000)

B. The 'cool' factor
   The game should have graphics, sounds and elements that are in trend with the gaming and tastes of the children. Additionally, the game must give the children a feeling that the interaction with the game accommodates their capacities and understanding (Brederode, et al., 2000).

To meet design goal A, the researchers designed the game to allow the players to collect creatures (those with most creatures win) and earn 'style applauds' which encourages the children to build challenging and varied tracks with the playing field elements. As a result, the children enjoyed experimenting with different tactics and game configurations (Brederode, et al., 2000). To meet design goal B, the researchers chose a clear graphics style for the game

elements with high contrasts which reflected the trends of children's computer games. In addition, they made the game mechanics simple enough such that the children had no issue understanding the relatively new technology (Brederode, et al., 2000). Thus, we can see that putting the children's enjoyment as one of the priorities during game design is essential. The next section 2.4 discusses intervention programmes utilising game environments for children with ASC.

2.3 Intrinsic Motivation in Children with ASC

To create an effective game for children with ASC, we will be analysing intrinsic motivation elements that may help contribute to their interest during play. As briefly mentioned earlier, combining a child's interest into the AR system would increase his/her engagement during play. This phenomenon is evidenced in the "Power Card Strategy" visual aid developed by educators and parents to assist children with ASC in making sense of social circumstances, routines, language semantics and the curriculum of daily life (Gagnon, 2001). The Power Card, as shown in Figure 6, consists of a picture of the special interest to the children with ASC (i.e. Big Bird) and a summary of a strategy used to solve certain problems (i.e. how to stay focused). As a result, the card serves as an effective reminder for the child when similar situation with the problem arises (Gagnon, 2001).

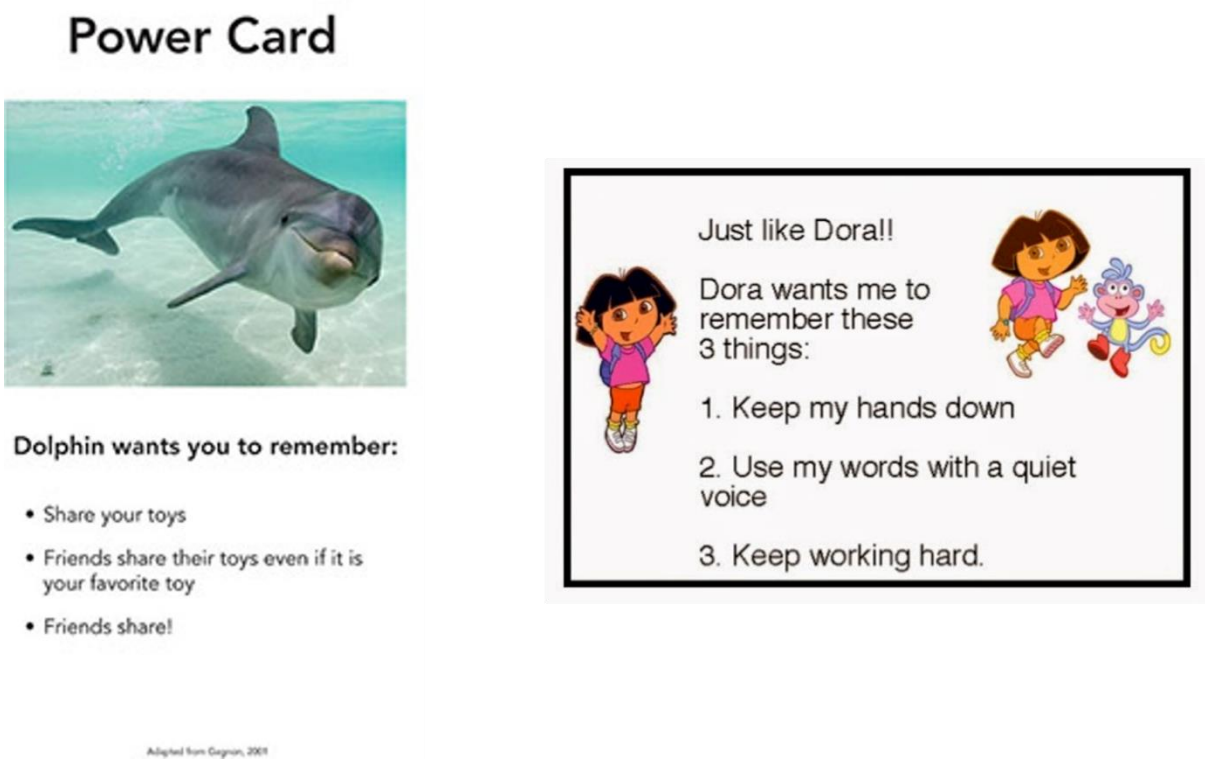

FIGURE 6. EXAMPLES OF POWER CARDS WITH DOLPHIN AND DORA AS INTERESTS. (OCALI, N.D.) (MY ASPERGERS CHILD, N.D.)

Another study has also found that incorporating highly preferred interests into the motivational techniques of Pivotal Response Treatment (PRT) resulted in a sharp increase in joint attention initiations for children with ASC (Vismara & Lyons, 2007). Moreover, the method can also be used to increase the child's social behaviour (Baker, et al., 1998).

Similarly, a study on the impact of being able to choose the order and game selection during a naturalistic language intervention confirmed that giving more freedom to children with ASC to choose aspects of game play results in decreased disruptive behaviours, increased levels of appropriate social play/pragmatic skills (Moes, 1998). Thus, the use of preferred materials, topics, activities, and toys in learning opportunities heightens an autistic child's intrinsic motivation to engage in required activities.

2.4 Augmented Reality

Augmented Reality is a general term for technologies that superimpose virtual contents onto the real world. As seen from the diagram below in Figure 7, an AR system comprises of a camera which inputs a video feed into a computing system. This computing system then merges the video with virtual objects from the graphics system resulting in an augmented video fed to the screen (Vallino, 1998). The end result is an augmented live video played on the screen.

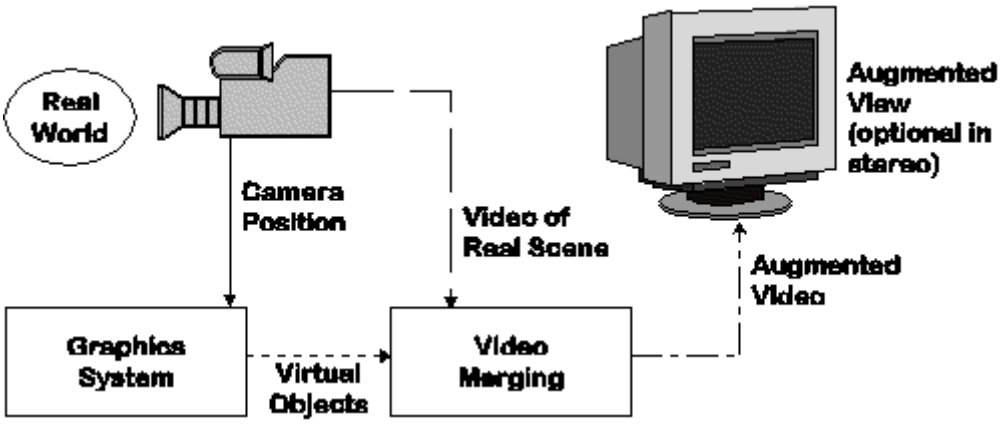

FIGURE 7. AN OVERVIEW OF AN AR SYSTEM (VALLINO, 1998)

The versatile AR system can be embedded in technologies in different forms such:

A. Head-mounted display
   The device is worn on a user's head with a display in front of his/her eyes.
B. Screen-based display
   Desktop monitors and large projection screens are used to display the AR content which is usually fed from an external camera or webcam.
C. Handheld display
   Tablet PCs and smart phones are used to display the AR content from the camera embedded in the device.
D. Projection-based display
   The AR content is displayed via projection onto physical objects such as walls or tables. No registration is involved from the flat surfaces.

Usually, during an interactive AR session, objects being recorded by the camera will be mobile. Thus, to anchor virtual contents onto the objects of focus, the AR system will have to recognise and track the object in the real world (Vallino, 1998). The tracking can be done via

vision-based tracking[4] or sensor-based tracking[5]. As the device used for this project will be a tablet (i.e. Samsung Galaxy Tab A), the available options for handling are either B, using the front camera, or C, using the back camera.

2.4.1 Design Considerations

Due to the flexibility of AR system design, it is important to make the system as user-friendly as possible. Based on the ISO definition, usability comprises of three distinct components (ISO, 1998):

1. **Effectiveness**
   The accuracy and completeness with which users attain specific goals.
2. **Efficiency**
   The efficiency of attaining specific goals given available resources.
3. **Satisfaction**
   The amount of comfort and positive affect the user experiences while using the system.

Thus, to design an AR system benefiting developing children in pretend play, there are several considerations to be reviewed:

A. The cognitive mechanism of pretend play should be used to identify areas being supported by the AR system, optimising the potential of AR to promote child development (Bai, 2014).
B. The AR system has to take into consideration the diverse developmental abilities of the children within the certain age range as for some children, more mental effort would be needed to understand symbolic thought (Bai, 2014).
C. To promote the children's engagement with the AR system, individual interests has to be taken into account. This is especially true for children with ASC as they are more likely to express restricted interests on specific topics (Bai, 2014).

These design considerations can be inferred from some examples below of related work.

[4] Vision-based tracking requires computer vision technologies to track a marked or unmarked object.

[5] Sensor-based tracking utilises sensors such as gyroscopes, accelerometers, GPS etc. to track an object.

2.5 Methodology

2.5.1 Forming Research Question

From the reviewed literature and the related work that was presented, five things become clear:

1. Pretend play is an act of substituting an imaginary situation to satisfy one's personal wishes and needs. This is why the play action would require the child to create a narrative or tell stories to serve the purpose of pretence. By coming up with problems in which the imaginary conjured object can solve or alleviate, the child is constantly engaging in a fabricated fictitious world of his own.

2. Children with ASC have difficulties when trying to engage in pretend play. This can be caused by their difficulty in understanding other's mind (theory of mind) and the challenges they would face in symbolic thinking and organising play thoughts due to their less developed pre-literacy cognitive skills.

3. There are multiple reasons why children with ASC will benefit from engaging in pretend play such as becoming more competent at convergent and divergent thinking, perspective taking, impulse control, socialisation, language literacy and healthy growth of emotion.

4. Utilising AR systems can help elicit pretend play behaviour in children with ASC. As suggested, an AR system can increase the child's understanding of symbolic thinking and consequently, increase his/her frequency of engagement in pretend play, maintain longer pretend play duration and keep their play ideas more consistent to a suggested theme.

5. Increasing intrinsic motivation in children with ASC is crucial to their learning experience. Allowing the child to incorporate his/her highly preferred object of interest or integrating choice making into the child's task can improve his/her performance on a learning task while also increasing his/her joint attention skills, social behaviour, and decreasing disruptive behaviours.

These findings suggest that an AR game app can be used for children with ASC to facilitate their involvement in pretend play. This raises the question whether children with ASC can be taught to initiate pretend play and whether they would be able to transfer what they have learnt into real-life situations (generalisation). However, answering these questions directly is beyond the scope of this research because it requires long-term studies to observe whether any generalisation took place. Thus, a more specific question is posed:

How to design a game that encourages children with ASC to pretend play?

The first step to answer this question is to establish a game framework that encourages pretend play behaviour. The second step would be to propose a methodology for developing a game within this framework that will be suitable for the target group.

2.5.2 Game Framework And Research Questions

The game will be aimed at children with ASC who has little to no skills in pretend play. Thus, some of the aspects of pretend play are structured such as:

- the game's storyline
- imaginary object creations in the form of models to be augmented

Choice making and physical object manipulation will be the main actions required by the player. As mentioned in the literature review, physical manipulation also helps to increase appreciation of symbols in pretence. These design framework decisions, thus, allow the child to engage in pretence at the simplest level without having to struggle with other road blocks of pretend play such as convergent thinking. This ensures that he/she will find it easier to understand the concept of having symbolic thoughts as compared to having no guiding structure at all.

Moreover, increasing the player's intrinsic motivation will be the main focus of the game design so that he/she associates the type of play with positive feelings. Thus, encouraging the child to initiate pretend play actions independently.

The central theme of the game app development process will be based on the following research questions (which are based on Human Computer Interaction (HCI) principles further elaborated in Chapter 4):

1. **Usability:** Is the AR game appropriate for children with ASC?
2. **Satisfaction:** Will the target group in general find the AR game fun and engaging?
3. **Utility:** Will the AR game be effective in encouraging and supporting pretend play behaviours in children with ASC?

2.5.3 Participatory Design

Within its rough framework, the game's content such as the narrative and the types of augmentation objects still need to be designed. This process would involve user-centred design methods and the methodology chosen for this research is the participatory design (PD) process which involves communicating with the user as a co-designer during all stages of the design (Bratteteig & Wagner, 2014). The method allows the designer to gain expert knowledge from the target users and gives power of decision to those who will be using the end product. To overcome communication barriers when it comes to design, the designer utilises tools such as prototypes (mock-ups).

A PD approached-based cooperative inquiry which focuses on children as the target users is used to gain their insights during the design process (Druin A. , 1999). Cooperative inquiry includes activities such as sketching ideas, brainstorming or observational research (modified to accommodate the children's preferred approaches) (Druin, et al, 2013). During this process, the children will play an active role as research partners and work with together with the product developer to conceive, develop and produce the technology (Druin, et al, 2013). Thus, extensive involvement of the child designers is required during the period.

As the research's target user group consists of children with ASC, conducting a cooperative inquiry within a short period of time on the group may cause too much stress to the children as they may find novel situations, interactions with strangers and imaginative work overwhelming. Thus, given the time constraints of the research, it would be infeasible to work with them as short and effective design activities are required.

As a result, typically developing children are used as proxies for children with ASC in this research. To cover the grounds uncovered by TD children during design sessions, experts who have experiences working with children with ASC are used to give feedback on how children with ASC will typically respond to certain design choices. Inquiring the experts who have had direct relationships with children with ASC is a common design method used to build technological systems for the target group (Hirano, et al., 2010) (De Leo & Leroy, 2008). Thus, experts from different backgrounds related to Autism, HCI and Education will be involved to give feedback and advice on high-level design decisions before and after implementation. Semi-structured interview sessions will be conducted and their input will be used to structure the game app development.

Lastly, a set of design principles for developing technology for young children and children with ASC will be consulted in the development of the game framework (in Chapter 4) to clarify design objectives.

2.5.4 Research Structure

The summary of the PD methodology used to guide this project's development is shown in the diagram below:

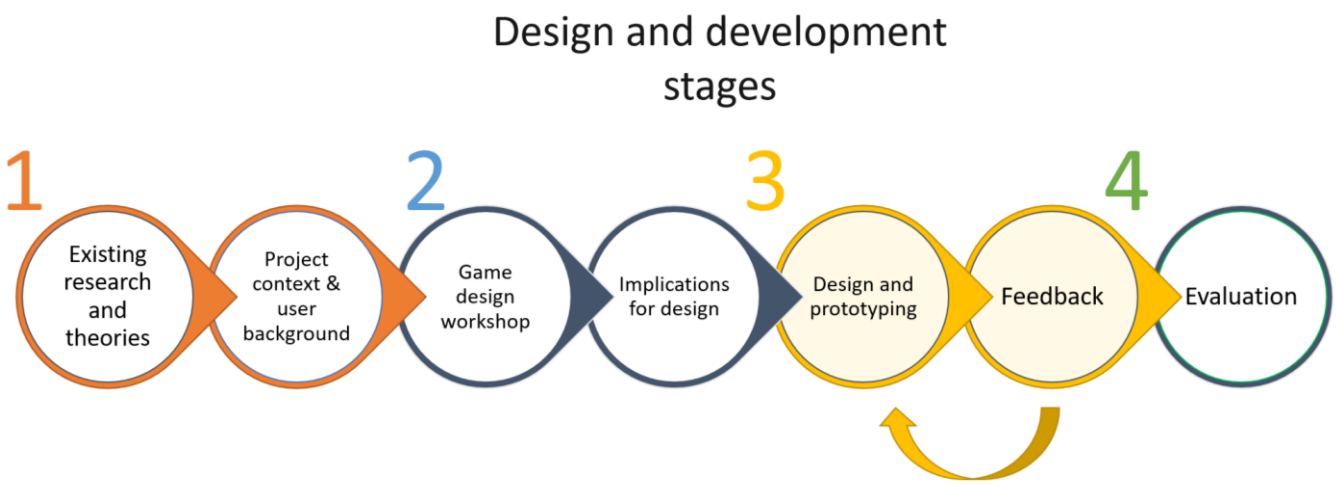

FIGURE 8. DIAGRAM OF DEVELOPMENT PLAN

1. **Defining research questions**
   The aim of this stage is to understand the needs of the target population of the game app and determine where work should be targeted by carrying out an extensive study to understand the user's requirements, elements and benefits of pretend play, and the effectiveness of related systems used so far.

2. **Informing the game design**
   This stage takes in feedbacks from planned activities with TD children to inform the game design (game design workshop). The main aims for these activities are:
   a. Get feedback on how young children would typically interact with an AR system on the tablet through observation.
   b. Get game storyline ideas through planned activities.
   c. Get game augmentation object ideas through planned activities.

   Observations were carried out with young children (aged 6-11 year old) interacting with a basic AR application after which they were asked to help design the game, story and characters. A set of requirements are then established from the design workshop.

3. **Design and prototyping**
   At this stage, development of the game application starts with the creation of low-fidelity prototypes based on the design requirements gathered from stage 1 and 2. After that, expert feedbacks are gathered and the game prototype was revised iteratively to accommodate for any potential improvements. Finally, a pilot test with TD children is used to detect any further usability issues that may have been overlooked and alert the designer for changes needed to be made before the evaluation stage.

4. **Evaluation**
   The final game application will be tested on a group of TD children to evaluate the usability and user satisfaction of the final prototype (game testing workshop). Suggestions for any further improvements are also welcomed. After that, the game will be evaluated by the experts so that they can give their feedback on the effectiveness of the app on children with ASC.

Chapter 3

Pre-design Stage

3.1 Observations on Handling AR Device

3.1.1 Aims

The aim of this observation was to see how young children (aged 6-11 year-old) interact with an augmented reality app on a tablet and the marked wooden blocks which are augmented with 3D models on them. The ease of use and how they played with the augmented objects in a handheld AR system are observed so that informed design decisions can be made later on. The handheld design was chosen because it was assumed that the children would not have to divide their attention as much as a screen based display.

3.1.2 Observation Design

3.1.2.1 Participants

There was a total of 5 boys and 18 girls age ranged from 6 to 11 year-old. Their literacy levels were sufficient to understand instructions and express themselves.

TABLE 1. SUMMARY OF PARTICIPANTS FROM 3 DESIGN WORKSHOPS

Workshop 1			
Child	**Sex**	**Age**	**Siblings**
1st Group			
S1	F	11	
S2	F	9	
S3	F	8	
S4	M	11	Yes
S5	F	9	
S6	M	7	
2nd Group			
S7	M	7	
S8	F	5	Yes
S9	F	5	
S10	M	6	

Workshop 2			
Child	**Sex**	**Age**	**Siblings**
1st Group			
S11	F	9	
S12	F	8	
S13	F	8	
S14	F	7	
S15	F	8	
2nd Group			
S16	F	8	
S17	F	9	
S18	F	7	
S19	F	9	
S20	F	7	
S21	F	7	

Workshop 3			
Child	**Sex**	**Age**	**Siblings**
S22	M	7	Yes
S23	F	9	

3.1.2.2 Setting

Three workshops were carried out in a comfortable environment while one was carried out in a games hall environment. No parents were present in the duration of the workshops. The children were free to choose whether to participate in the session or not, and are free to discontinue participation if they wish to during the session. The observation lasted for approximately 15 minutes before the next part of the workshop is implemented.

3.1.2.3 Materials

FIGURE 9. MAIN MATERIALS USED FOR THE WORKSHOP

The materials used were a Samsung Galaxy tablet, some wooden blocks and printed markers on them as shown by Figure 9. The application used was built using Vuforia[6] augmentation package on a Unity 3D game engine[7]. Vuforia extracts feature vectors from the preloaded markers image file (unique high contrasting, detailed, asymmetrical images) and then loads these feature vectors into a predefined 'camera' object in Unity environment. During run-time, the 'camera' object then detects these feature vectors when it sees a marker and display an object model over that marker on screen as shown in Figure 10. For the workshop, the AR system is of a hand-held design (right-hand side of Figure 10) as it is more mobile and enable better viewing of 3D augmentation objects.

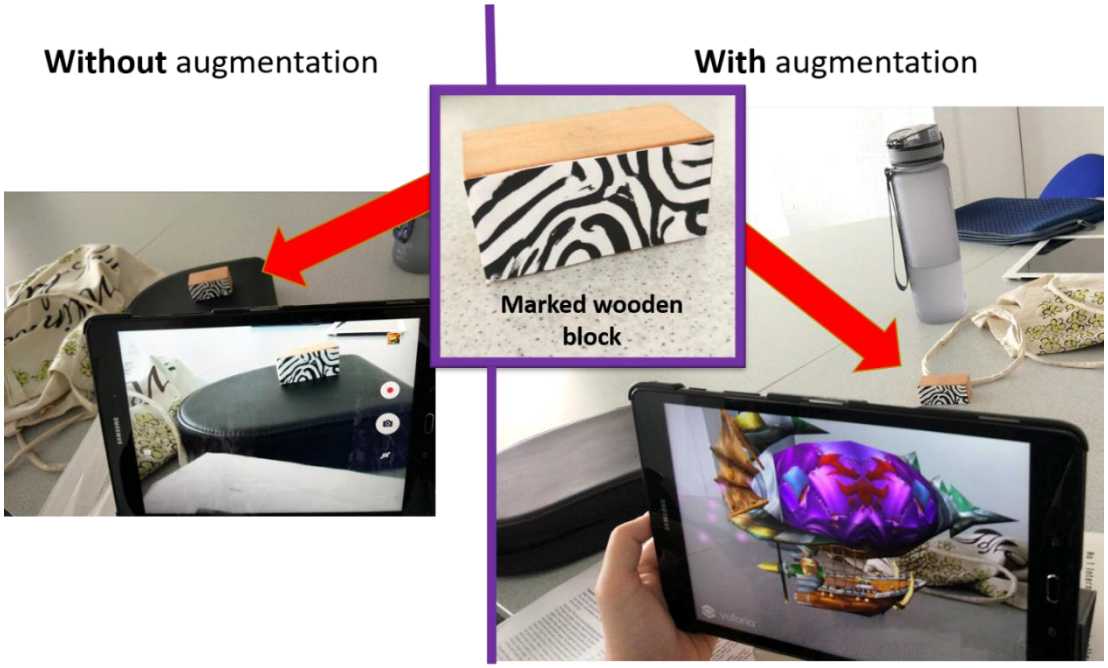

FIGURE 10. EXPLANATION OF AR SYSTEM

[6] https://www.vuforia.com

[7] https://unity3d.com

FIGURE 11. EXAMPLES OF AUGMENTATION OBJECTS: A SPACESHIP, A TRAIN AND A BRIDGE

While building the application, it was noted that markers that are more colourful (shown in Figure 12) tend to have problems being detected by the application when printed onto the small wooden blocks (2.6cm x 2.6cm x 5.4cm and 2.6cm x 2.6cm x 5cm). This may be because the camera could not focus properly on the small images and thus, minute details could not be captured to be converted into the required feature vectors. Thus, black and white abstract patterns were used instead because they have defining high contrasts and therefore, are easily detected.

FIGURE 12. COLORED MARKERS TESTED

Also, an information sheet was given to the parents to explain the study, its aims and the procedure (see Appendix D). A consent form was also handed out to the parents to get their consent (see Appendix B). A child consent form was also produced (see Appendix A).

3.1.2.4 Procedure

After the parents, had been provided with the information sheet and the consent form, formal consent was gained. The children were also given explanations about what they were going to be asked to do and were ensured that they were not obliged to participate and could withdraw from the observation at any point in time (see Appendix C). Then, the children were asked to sign the child consent form.

The session is video recorded while the researcher is engaged with the children so that their behaviour can be observed and noted down later after the workshop. The children were told that they were participating in the session to help design an augmented reality game.

3.1.3 Observation

3.1.3.1 Setting up

The group of children were asked what augmented reality was then introduced to the application on the tablet and shown the augmented wooden blocks. The tablet and the blocks are then handed to them so that they can play around with it for some time.

At the beginning, children across all the three workshops took some time to adjust handling the tablet so that the markers can be detected. There are a few possible obstacles noted for the markers to be detected whilst handling:

- **Distancing**
  The patterns on the marker has to be fully seen by the camera in order for the application to detect it. Some children bring the wooden blocks too close to the tablet's camera so that parts of the marker get cropped on-screen, rendering it undetectable.

- **Camera to object position**
  Due to the position of the camera on the top left corner of the tablet and the small size of the blocks, some children have difficulty aligning the object to the camera and vice versa so that the object can be seen on screen.

- **Camera focus and lighting**
  Once in a while, even when both conditions are met above (marker can be seen on-screen), the application would fail to produce an augmentation because it has failed to detect the marker. This was due to the marker image being out of focus due to poor lighting conditions or the application not refocusing as objects are moved. Thus, the image marker is too blurry for its features to be detected.

After the markers have been detected by the application, more possible obstacles are noted in order for the children to view the 3D models on the tablet screen:

- **Distancing**
  Sometimes, the blocks were held too close to the camera and hence, the 3D model could not be viewed properly as it is too near (i.e. only a part of it can be viewed on screen).

- **Blocking with other objects**
  When some children try to put one block beside or on top of the other and hence, blocking the other block's marker, the 3D model would fail to show for the blocked marker.

- **Rotation**
  Some children when caught up in manoeuvring the blocks rotate them, thus, the marker cannot be viewed fully and the 3D model would fail to show.

Out of the 5 sessions across the workshops, it was noticed that the time for the children to adjust to handling the tablet and the blocks is related to whether the tablet was initially in

their hands or on the table. More problems from the above points arise when the tablet was initially positioned on the table. This is because the application runs best when the tablet is at an angle to the wooden blocks. The children are less likely to adjust the height of the tablet when the blocks cannot be seen on-screen or when the markers could not be detected if the tablet is initially stationary on the table. They would instead try to move the blocks too close to the tablet or below the tablet's camera such that the view of the blocks is out of range.

3.1.2.2 Play behaviour

Most of the children were enthusiastic and inquisitive with the technology and the augmentation's 3D models. Their play behaviour was a mixture of functional play based on the 3D models (i.e. trying to put the train on the bridge or let it fly in the air) and exploration. Some of the children would:

- Put the camera over any images assuming they are markers and ask "Can this change?"
- Put two augmented blocks together to see if the 3D models would interact with one another i.e. while playing with the blocks, some children asked "Can the train be on top of the bridge?", "What will happen if you put the train on the ship?"
- Position the augmented blocks on top of drawings to see what happens. One child asked "Can this change?"

3.2 Observations on Game Design

3.2.1 Aims

The main aim of this observation was to see how the children respond to the theme and basic design of the game story, structure, prompts and goals. The session is structured around open-ended story telling whereby the first half of the story was told to them and the second half was meant to be completed by them. The purpose of this structure is so that the children will get used to the idea of objects transforming and understand the element of the game play which consists of coming up with a creative transformation in order to solve a problem.

3.2.2 Observation Design

3.2.2.1 Setting

This part of the workshop took about 20-25 minutes to complete and is a continuation of the previous session on AR handling.

3.2.2.2 Materials

As shown in Figure 8, a few materials were gathered to allow for game story telling:

- A PowerPoint presentation was made consisting of backdrops i.e. a fruit bowl, a river.
- Wooden blocks were designed with faces on them to give them characters.
- Colourful markers and papers

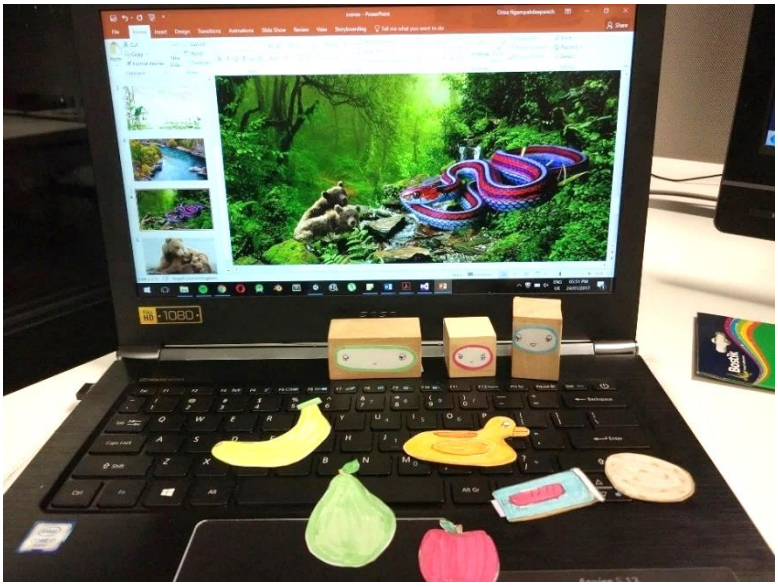

FIGURE 13. MATERIALS FOR GAME STORY TELLING

3.2.2.3 Procedure

Part I: Introduction and storytelling warm up

- Marked blocks and augmented reality application are shown to the children to give them an idea of what augmented reality is and how it will be designed into the game.
- Start the slide show and tell them the story of 3 wooden blocks magically enhanced to be able to perform ninja transformations.
    - Ask them what they would want the wooden blocks to be named i.e. Red, Blue, Green
    - Place the 3 wooden blocks in front of the slide show as shown in Figure 14.

FIGURE 14. START OF STORY

Slide 1: <Crate of wooden blocks >

[8]*On the day they became alive with ninja transformation powers, Red told his brothers "Guys, we've been here for ages! Let's go exploring! I'm sooo bored… There are just boring piles of toys waiting to be played with over here, why don't we go out?".*

Blue says "That's a great idea! Alright let's go!".

Slide 2: <Cat and fruit bowl>

As they left the play room and tumbled into the kitchen, they heard a tiny meow behind them. Red turned to look then whispered "What's that fluffy thing?!"
Green hurriedly whispered back "Guys! We must not let him see us! I've seen him scratched other toys into pieces before!"
Blue whispered "I have an idea! We can hide in this fruits bowl! Let's transform into fruits!"

*** *Stick *Pear* on Blue, stick *Banana* on Green and *Apple* on Red as shown in Figure 15.**

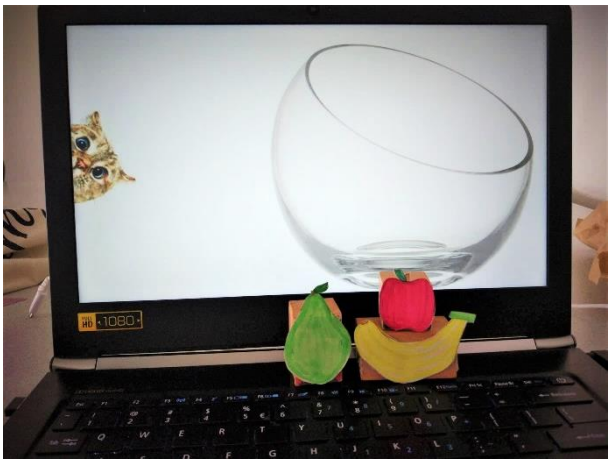

FIGURE 15. FRUIT BOWL SCENE

They stayed very still and waited for the cat to walk pass. The cat sniffed the bowl for a while then meowed and walked off to the living room. Green whispered "Quick! Let's get out of here!" and the brothers tumbled through the window that was open.

Slide 3: <Outside the house>

Finally, the three brothers made it out of the house. As they were looking around, Blue being the tallest, spotted a river not far away from the house with a dense forest behind it. He excitedly told his brothers "Let's get to the forest for our adventure!" and so, they headed to the river bank.

[8] Narrated

Slide 4: <River>

****Blocks are positioned on left side of the screen as shown in Figure 16.**

FIGURE 16. APPROACHED RIVER SCENE

As they reached the river they realised that they could not swim as wooden blocks. It is time for them to use their ninja transformation powers to get them across the river. Red had a great idea.
Pointing to Green, he said "I know! You can turn into a potato shooter and I'll turn into a potato shooter so you can shoot me across!"

**** Stick *Potato Shooter* on Green and *Potato* on Red. From the front of Green, 'shoot' Red across by moving him to the other side of the screen as shown in Figure 17.**

FIGURE 17. POTATO SHOOTER SCENE

Now, Green and Blue is left but Blue was stuck without any ideas.
Green turned into a rubber duck float and said "Don't worry brother! Hop on to me!"

**** Stick *Rubber Duck* on Green, put Blue on top of Green and move them across the screen as shown in Figure 18.**

FIGURE 18. RUBBER DUCK SCENE

The brothers hi fived each other and together, they walked deeper into the forest.

Slide 5: <Bear cubs>

After some time, the brothers came across two bear cubs. The cubs had just lost their mother and they were feeling very sad.

****Split the children into 3 groups and ask them to help come up with ideas for which objects the ninja brothers can turn into to cheer the bear cubs up by drawing their objects on small pieces of paper. Read out their ideas.**

FIGURE 19. BEAR CUBS SCENE

****Click on slide/ use right arrow key to animate cubs**

The bear cubs became really happy thanks to the brother's help! They became friends and started to play when suddenly, a poisonous hungry snake appeared.

****Click on slide/use right arrow key to introduce snake**

****Again, within the same groups, ask the children to come up with ideas for which objects the ninja brothers can turn into to protect the bear cubs from the snake.**

Having saved the bear cubs, the brothers decided to find where their mother is. Red asked them "So when and where was the last time you guys have seen your mother?"

The older cub replied," She said she was going to the river to fish for some food, but we have been waiting in the cave for ages but she has not came back so we went out looking for her and got lost instead."

The brothers knew the way back to the river so they lead the cubs back to where they came from.

Slide 6: <Mother bear>

FIGURE 20. MOTHER BEAR SCENE

Finally, as they were walking down the river bank, they found the mother bear! The bear cubs were overjoyed to see their mother again and they thanked the ninja brothers for helping them. In return for the favour, the mother bear gave the ninja brothers a magic dandelion which if blown upon, will teleport the brothers to anywhere they wish to go. However, it can only be used once.

<End of Script>

PART II: DESIGN BRAINSTORM

Within the same groups, ask the children to help continue the brother's adventure by drawing a place of where they would go to next and create a conflict which requires the brothers to transform and draw out what they transformed into. Suggest them a variety of examples i.e.:

- the supermarket
- the moon
- a pirate ship
- under the sea
- the playground

After the children are done, go around the groups and ask them to present their stories. Collect the drawings and reassure them that the drawings will be scanned and given back to them.

<End of design workshop session>

FIGURE 21. WORKSHOP STORY DISCUSSION SESSION

3.2.3 Observation

In general, the children had no trouble following the storyline at all with most becoming immediately engaged with the story and the main theme of transformation. Interests and enjoyment increased when they were asked to finish off the rest of the story.

3.2.3.1 Guided Transformation from Story Telling

The drawings from the children were annotated, counted and noted down in Table 2 and Table 3 for each scenario of the story.

TABLE 2. IDEAS FOR HELPING MAKE THE BEAR CUBS HAPPY

Scenario: Cheer the bear cubs up		
Theme	**Frequency**	**Example**
Food	9	Berries, **fish**, **honey**, cake
Companion	8	Mother bear, bear cub, unicorn
Aesthetically pleasing objects	7*	Cheerful emoji, rainbow, lemon
Entertainment	4	Beach ball, piano, playground, Uno cards
Miscellaneous	2	Mother bear finder, goodnight kisses

*Hint was offered (emoji idea from previous workshop) and many children copied it

From Table 2, it can be seen that most children would like food, companion or aesthetically pleasing transformations for when they want the bear cubs to be cheered up. This is due to they themselves being cheered up by the very things they suggested. This finding can also be integrated into the game design as a running theme to make it enjoyable. It was also noted that for a few children who had difficulty stuck generating ideas, when specific hints were given, some would copy it right away before becoming inspired to generate more ideas. Also, when the experimenter praised a child for his/her 'unique' work, the group of children tend to come up with more novel ideas (no one copying from the other).

From Table 3, we can see that during a conflict against a 'bad' character, most children would tend to attack it than escape. This may be because to children, confronting 'evil' is more exciting than defending others from it. Thus, incorporating the element of fighting a 'bad' guy into the game is a good idea. Also, it was noted that a few children got very excited over Pokémon and created extensive fight moves their Pokémon would rain down on the snake. Their Pokémon then went on to appear in the later part of the session where they were allowed to make up the story, commenting "This is so fun!" at the end of the workshop. This suggests that involving a subject of high interest in the game could improve the experience of the children during game play as mentioned in the literature review (Chapter 2.3).

TABLE 3. IDEAS FOR PROTECTING THE BEAR CUBS

Scenario: Protect the bear cubs		
Theme	**Frequency**	**Example**
Attack (harm to snake)	19	**fire**, **snake**, karate master, sword, spikes, poisonous arrow, Harry Potter, lizard, Pikachu, Charizard, lion, poisonous seaweed, loaded cannon, elaborate trap (sends the snake flying)
Defend (obstacle between cub and snake)	8	river, shield, bridge, wall, force field, poop
Escape (relocation to unreachable places)	2	(get in) floating bubble, teleporting portal
Neutral (no harm to either party)	2	honey (stick the snake to the ground), stupifier 2000 (makes enemy friendly)

Lastly, it was noted that colours play a very important role in the objects designed by the children. A few would wait for markers of a certain colour to be available while another child was using it i.e. While colouring her drawing, a child said “I need the red marker.”. As seen from Figure 10, the drawings are very colourful.

FIGURE 22. EXAMPLES OF DRAWINGS FROM THIS PART OF THE SESSION

3.2.3.2 Generating Game Story Scenarios

Again, the drawings are annotated, counted and summed up in Table 4 and Table 5. It was noted that less prompting was needed in this part of the session as the children has become used to the purpose of transformation and generating ideas. As seen in Table 3, the children prefer both idealistic and realistic world as settings for their story scene. However, it may also be due to the non-fantasy scene settings of the original story beforehand.

TABLE 4. IDEAS OF PLACES

Settings		
Theme	**Frequency**	**Example**
Idealistic (non-existing world)	10	ghost land, heaven, inverted macro-micro world, poop factory, medieval time, Jurassic time, magical animal kingdom, Lego world, portal, magical underwater temple
Realistic	11	water park, maze, river valley, beach, UK, supermarket, house, moon, toy shop, school

TABLE 5. IDEAS OF CONFLICT AND TRANSFORMATION

Story			
Theme	**Frequency**	**Conflict example**	**Transformation example**
Adventure	11	getting lost, drowning, prevent temple from collapsing, moon exploding	giraffe, fish tail, air molecules, a few types of whales, rocket
Fighting bad guys	9	evil jellyfish, tongue of doom, evil king, t-rex, evil Lego robot, bullies	ninja, poop, super finger, swords, guns, rackets, throwing stars, super glue, Lego building manual, ruler

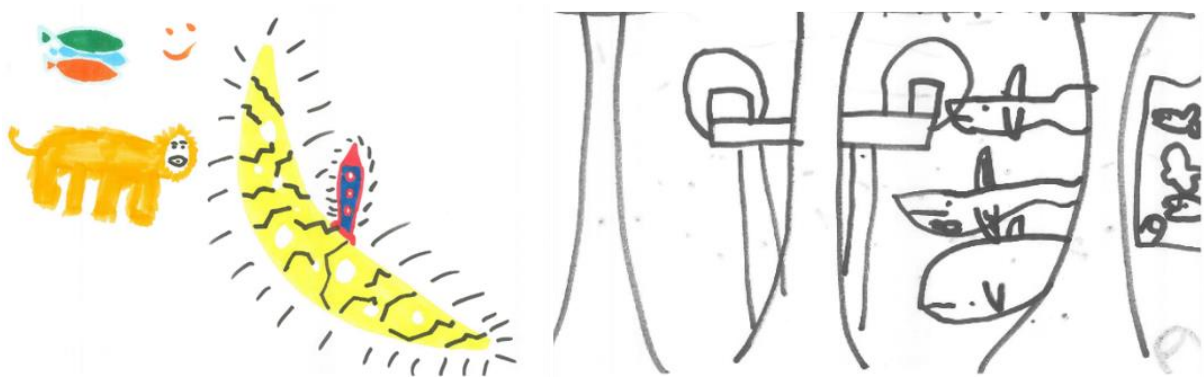

FIGURE 24. DRAWINGS OF EXPLODING MOON AND UNDERWATER TEMPLE STORIES

Similarly, there is about equal interest in adventure and fighting 'bad' guys theme within the scenarios generated by the children as seen in Table 5. During the session, it was noted that the children were giggling when it came to 'poop' humour whereby the transformation object is poop. This sparked a series of poop drawings (i.e. right of Figure 25) and laughter.

FIGURE 25. DRAWINGS OF A FAIRY SAVING THE BROTHERS FROM A TICKING BOMB AND POOPLAND STORIES

3.3 Discussion

There were several observations made that informed the design of the project:

1. <u>Difficulty in handling AR system</u>
   Even for developing children without ASC, an AR system may be challenging to use. Hence, it is of utmost importance that the interaction between the child and the system is as simple as possible. Having faulty augmentation due to handling can severely reduce a child's engagement when playing with the system.

   Further research was made into how different designs affected the use of AR systems for developing children. It was found that having the screen in front of them during play (display-based AR system design) results in the least confusion and difficulty encountered (Radu & MacIntyre, 2012). This is because young children have difficulty holding attention on multiple things at the same time. As observed during the workshop, there were two things a child would be trying to do at the same time: seeing the augmented object on screen and trying to not lose track of the marker by positioning the camera. As there are two objects movable at the same time i.e. the camera and the marked object, the children has found it difficult to coordinate their movements.

   Additionally, even if the child chose to place the tablet statically on the table, he/she would still have difficulty viewing the augmentation. It was found that due to the length of their arms, the object being held in front of the tablet's camera would normally appear too big on the screen and further adjustments need to be made.

2. Intrinsic motivational factor
   It was noted from the workshop that children who put their favourite character i.e. Pikachu into their game story became excited and were more likely to form many scenarios for the game story line. Thus, this suggests that emphasising their interests in the game stories may increase the likelihood of the children engaging in more play behaviour.

3. Appropriateness of story structure for pretend play
   The children readily grasped the concept of the 'transforming ninja blocks' through the story told. This implies that the storyline structure can be effective in teaching pretend play. Although their pretend play skills are advanced enough for them to completely create new story scenarios from scratch, it is important to understand that children with ASC will have a much lower set of skills in this area. Thus, the actual game will be utilising the storyline structure but the 'creation of pretence' will be at a much easier level.

3.4 Outcomes

The observation conducted have contributed to the understanding of the difficulties that arise when young children interact with an AR system. Although the size of test groups was limited in the studies, the results suggests that the children will have less difficulty interacting with a screen-display AR system design. Also, less guidance in understanding the game's transformation element is needed after fully guiding them at the start of the game story. The design workshop concludes the following requirements:

1. The design should utilise the tablet's front camera for a screen based AR system design.
2. The game should include the child's object of high interest.
3. The game should have aesthetically pleasing design such as colourful items and animations.
4. Incorporate both themes of adventure and fighting against 'evil' guys as game play design.
5. Incorporate food, companion and aesthetically pleasing objects themes into the game environment design.
6. The game should include steps to introduce the child to the game concepts before making the game mechanics more open-ended.
7. The game objects should be interactable.
8. Odd humour should be incorporated.
9. The game story should be narrated in a way that is similar to that of the Ninja blocks story where conflicts are created only to be solved via transformations.

CHAPTER 4

GAME DESIGN

In this chapter, the game design will be further developed by incorporating good design principles together with the inputs from the literature review (Chapter 2) and the workshop (Chapter 3). In addition, the usability and design experts' opinions and feedback on the draft design ideas and prototypes will be used to improve the game iteratively. Lastly, to test and improve the game before evaluation, a pilot test was conducted with the children.

4.1 DESIGN PRINCIPLES AND REQUIREMENTS

The project is aimed at children with ASC who lack pretend play skills and the game experience will be designed such that the players do not need adult assistance or require as little assistance as possible. From the literature review, the cognitive age of typical developing children at this stage is around 3-4-year-old. Thus, the game app will be targeted at children with ASC with the mental capability of pre-schoolers. According to the Human-Computer Interaction (HCI) principles, to develop a good user-centric interactive system, usability goals and user experience goals have to be taken into account. The primary objective here is to design an entertaining and engaging game so that it motivates a child with ASC to initiate more pretend play activities. Hence, the interactive AR game should be easy for the children to learn to use, effective and fun from the children's perspectives.

Firstly, HCI usability goals will be consulted to understand the necessary checkpoints a system will need to have in order to fulfil the criteria of having a high usability level.

A. Usability goals:

1. **Effectiveness and Efficiency**
   Effectiveness generally measures how well the system does what it is supposed to do (Issa & Isaias, 2015). Thus, in context, the design will be centred on providing methods that achieve the goal of encouraging pretend play. To reiterate, pretend play refers to substituting a situation with another imaginary situation to satisfy one's personal needs and wishes for fun. Thus, the game app will be teaching the children how to perform substitution to satisfy a need by forming imaginary situations through storytelling. Efficiency measures how well the system supports the users in completing their tasks (Issa & Isaias, 2015). For example, in the design, the children should be able to complete their task of transforming game objects in the simplest way possible i.e. by pressing a button.

2. **Safety**
   Safety measures how well the system protects the users from undesirable situations (Issa & Isaias, 2015). This especially means that the AR system in the game will have to work at its optimum responsive level with as few glitches (untraceable marker errors, etc.) as possible. Moreover, the overall game application has to be 'unbreakable' in a way that all the interactive objects reacts to a specific type of user

input, i.e. a tap, and that they are big enough for developing motor skills. Additionally, intuitive navigational icons will be implemented in the design so that the children can undo any 'incorrect' decisions.

3. **Utility**
   Utility measures how well the system lets the users do what they need or want to do by providing them with the right type of functionality (Issa & Isaias, 2015). For example, the game design will be accommodating to the children's wide range of interests and preferences so that they will be inspired to transcend these ideas into their pretend play sessions.

4. **Learnability**
   Learnability measures how easy it is for the users to learn to use the system (Issa & Isaias, 2015). This implies that the design should be as intuitive as possible for children with ASC to minimise unnecessary learning blocks.

5. **Memorability**
   Memorability measures how well the user will be able to remember how to use the system after he/she learns it (Issa & Isaias, 2015). For example, the game design should have as minimal amount of memorisation needed as possible for usage through simple design. For the game, the child will have to remember what each navigational button does and how to hold the block to the camera for there to be augmentation on-screen.

Having explained the usability goals, the next step is to show what will go into reaching the user experience goals which aim to make the game fun, satisfying and motivating for children with ASC:

B. User experience goals:

1. **Fun**
   a. Giving the children the freedom to proactively choose what to pretend by giving them the choice to choose and assign augmentations to the AR object. As the number of choices in the game should reflect the respective cognitive skills of the players, fewer choices are ideal (two to four options) (Dunlap & Liso, 2004).
   b. By tailoring the themes of the game objects around things that get children excited.
   c. By letting the children choose the order of stages they would like to go to in the game.

2. **Satisfying**
   a. By minimising triggers that cause annoyances and frustrations for children with ASC. This means that the game structure has to be kept as constant and predictable as possible. This design concept will be further examined below.
   b. By slowly introducing the children to new concepts and environment with detailed yet simple instructions and game storytelling.

c. Giving the children shareable results from their play by taking pictures during AR scenes. This is mentioned in Zhen Bai's study where the participants wanted their play to be made shareable with other children (Bai, et al, 2015).

3. **Motivating**
   a. By utilising effective reward system with dynamic stimuli components. (Further explained below.)
   b. By disallowing any incorrect 'choice' within the game and thus, every decision has positive outcomes. This is because lower functioning children who have experienced social and communication failures were found to have significantly lost their motivation to perform (Clark & Rutter, 1979).

With over forty years of practice and fifty studies on designing touch tablet experiences for pre-schoolers, the Sesame Workshop organisation has put together some useful design guidelines for tablet game applications (Sesame Workshop, 2012). Now, we will be looking at the relevant practices mentioned while keeping in mind the different experiences children with ASC might have in certain conditions by also considering the design reflections concluded by Zhen Bai on building AR systems for children with ASC and design guidelines from Bartoli et al on designing games for children with 'medium-low functioning' autism (Bai, et al, 2015) (Bartoli, et al, 2014):

C. System Design Requirements

1. **Familiar faces in new places**
   The authors from the Sesame Workshop recommended utilizing familiar character(s) throughout the learning process because it is important to build a feeling of friendship and fun between the child and the character(s) to improve engagement and dialogue. As a child with ASC would have an affinity for technology because of its simplicity and predictability, this practice supports the theme by providing a sense of repeatability and predictability within the game app in the form of familiar character(s) (Bartoli et al, 2014). Moreover, Bai mentioned that children with ASC would easily become anxious when they are introduced to new activities. Thus, having one focused entity they can quickly become accustomed to would help alleviate this problem.

2. **Interactive design**
   According to another Sesame Workshop practice, when instructing the player to complete a task, stating the objective and how to accomplish that objective would help the child to comprehend what they should do next. However, as noticed by Zhen Bai from her experiments, the level of impairment in language delay and joint attention should be taken into account when specifying the target group as it would be difficult to explain to the child how to interact within the AR game. Thus, the game would be aimed at autistic children who are in pre-literacy or very early stages of literacy which means that they are able to understand basic spoken language. The game will try to aid those with low joint attention skills as much as possible by keeping them engaged.

   Another piece of advice from Sesame Workshop authors is that feedback is essential in forms of encouragement and reaction to user input. This practice is supported by

Bartoli et al as they also mentioned that children with ASC respond well to rewards or stimuli because the features increase motivation and make the game more enjoyable. The authors also suggest that as children on the spectrum do not value typical reward systems (i.e. points or coins), dynamic stimuli can be used instead. Examples of dynamic stimuli are short video animations, cheerful music or applause. Moreover, it was stressed that static images can quickly induce boredom which may then causes undesirable or repetitive behaviour. Thus, the use of animations throughout the whole game is encouraged.

Moreover, Zhen Bai also mentioned that using a selection of available AR objects of different types, shape and colour can persuade children with ASC to take part in the new activity (playing the game) as they are prone to having very restricted interest. Increasing the variety of AR objects increases the likelihood of the child being engaged.

Lastly, another practice recommended on interactive design is having context-specific dialogue and visual reinforcement as a 'Help' feature during the game. As we are aiming at preschool level literacy, the children will not be expected to read.

3. **Gesture**
   For young children interacting with touch screen systems, the most intuitive gesture is found to be tap as observed by the Sesame Workshop authors. Thus, the game will consist only of tap input type to keep it as easy to play as possible. (One tap per task. No double tapping as it is less intuitive.)

4. **Screen design**
   To achieve a game play goal, the steps required should be immediately and intuitively obvious on each screen. This means that the interactive elements (i.e. buttons) for fundamental actions should be more eye-catching and visually distinct from the rest of the screen. Also, similar concepts and functions should look similar to each other and be grouped in the same area of the screen. However, it should be noted that the objects on the screen should not be overlapping with one another and that there should not be too many graphics on-screen. Bartoli et al explained that children with ASC are easily overwhelmed by too much simultaneous information and thus, only relevant graphics and animations should be shown at any one time to keep the children focused and alleviate anxiety.

   For storytelling, the Sesame Workshop authors recommended freezing all hot spots and interactivity until after the story has been read for the scene. Also, as pre-schoolers have developing fine-motor skills, hot spots must be large and spaced out from each other.

5. **Visual layout and design**
   The Sesame Workshop authors also found that children do not normally pay attention to audio instructions alone and thus, a corresponding visual component would help to get their attention. Moreover, an indication of interactivity is needed when transitioning from a linear experience to an interactive experience. This includes active and touchable items having strong visual highlight (commonly yellow) so that children

will know that it is interactable. As the game will mainly use buttons as navigational tool, it is also good to note that the icons on the buttons should be as consistent and representational as possible by following the standard convention.

6. **Audio design**
   Specific (and minimal) instructions should be put at the end of the sentence with visual supports as children do not typically pay attention to audio instructions. Also, as children tend to be impatient, audio prompts should be interruptible while with storytelling, the page should be uninterruptable to increase the players' focus and story comprehension.

   Sound effects are also recommended as immediate touch input feedback as they are effective input registration communicators for user actions. Also, a consistent sound effect or a change in background music should be used to emphasise the transition from linear experience to an interactive experience.

4.2 Low-Fidelity Prototype Design

4.2.1 The Game Concept

All of the different aspects of design requirements, workshop feedbacks and theories from the literature review will form the basis and motivation of the prototype design. The end product of this stage will be criticised by usability experts in the next stage so that further improvements can be made to the current game design and ideas. The usability goals [A1], [A2], etc. user experience goals, [B1], etc. and system design requirements, [C1], etc. are annotated in this section as reminders of some design justifications made.

4.2.1.1 Game World and Story

The game will initially introduce the child to the concept of the 'ninja block' story told in the workshop. The difference between the new version and the old is that instead of having three character (the ninja brothers), there will only be one character for the child to focus on throughout the whole game [C1]. The setting of the story will be a magical world whereby a wooden block can teleport via a portal (idea from design workshop) and have transformation powers. It was mentioned that children on the spectrum will not have any difficulties following the fantastical storylines, although it was also advised to only narrate it from a third person point of view to avoid any identity confusion (Reichert, 2015).

As shown in Figure 26, the introduction of the game will lay out the structure of each subsequent game stages (Scenes 1-5) and instruct the player how to handle the wooden block in the AR scenes (Scene 4). This section of the game is very important because the children who are more sensitive to new changes might get uncomfortable seeing the augmentation on the wooden block. Thus, care is taken in making sure they understand what is going on [A4]. Scene 2 was added to emphasise the transformation of the block. Also, as seen in Scene 3, 'Click me' instructions will be given for the children to navigate to the AR scene in Scene 4.

In the scene, the child will be taught how to position the block so that he[9] will be able to view the augmentation. Scene 5 shows the positive reinforcement for the story whereby the conflict from Scene 1 goes away due to the 'action' of the player.

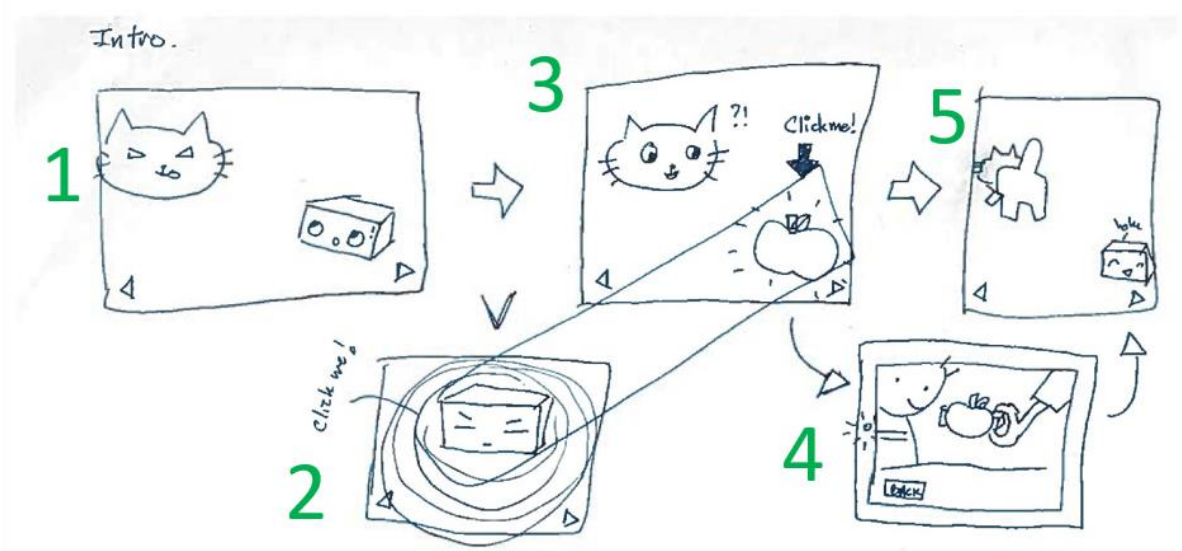

FIGURE 26. DRAFT INTRODUCTION STRUCTURE

Also, each story scene will have a back and forward buttons at the bottom of the screen so that:

a. Should the child want to replay the previous scene because he did not catch the narration, he can go back to listen to it again. This aligns with the safety section of the design requirement to make user error undoable [A2].
b. If the child has already played through the scenes before and already knows the story, he can move on forward without becoming annoyed by the uninterruptable audio [C6].

[9] 'he' is used here but the term is also representative of female target users

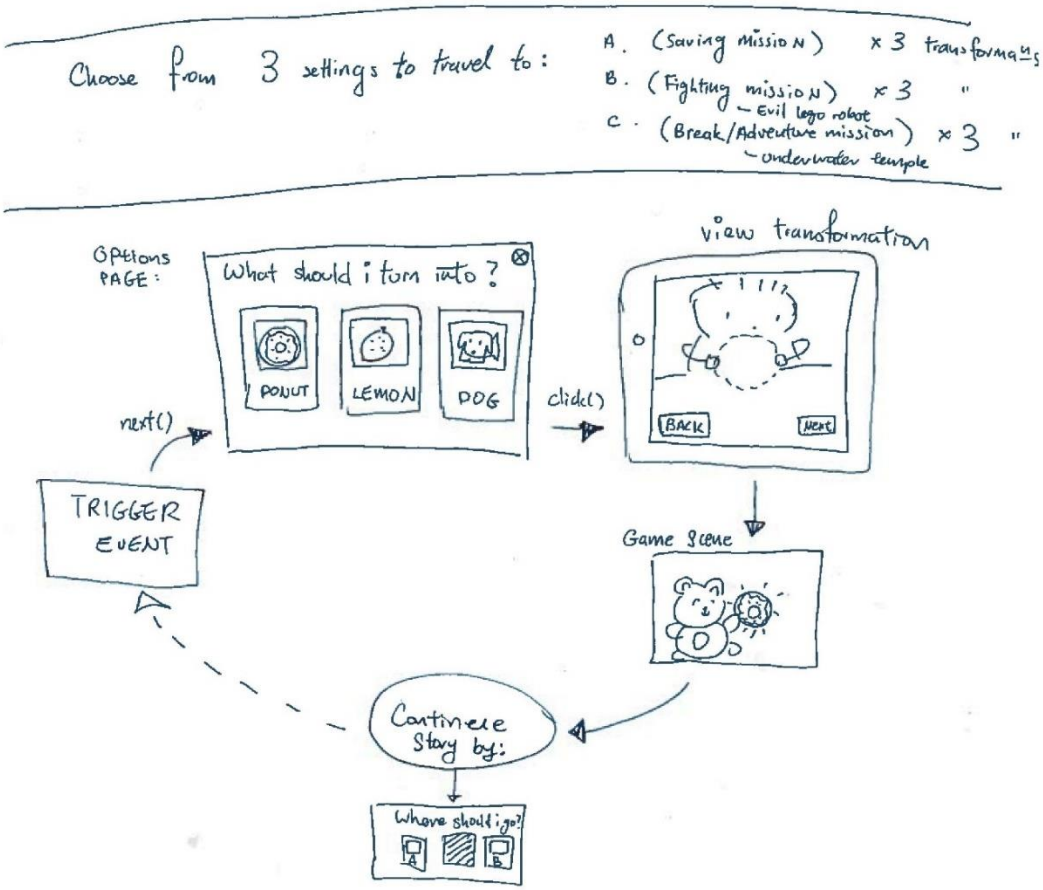

FIGURE 27. DRAFT DESIGN FOR GAME STRUCTURE

Figure 27 shows the planning for the overall game story structure. As seen from the top panel, there will be 3 mini stories consisting of saving, fighting and adventure missions in different settings (suggested by the workshop). All of them have the exact same structure shown in the cycle whereby a trigger event scene (the conflict) would be right before the transformation options scene [C6]. This reinforces the theme of object substitution to solve a problem [A1]. After the player selects an object for the block to transform into, the AR scene will appear right after so that he/she can view the transformation on the wooden block. The next scene will show the happy consequence of the transformation after which the mini-stories selection menu will appear so that the player can decide where the block should go next [B1]. The consistency and predictability of the structure aligns with the design requirement mentioned earlier [B2]. Moreover, this helps to ingrain the pattern of cause and effect in the child's mind so that the concept of pretend play is understood or at least encouraged [A1].

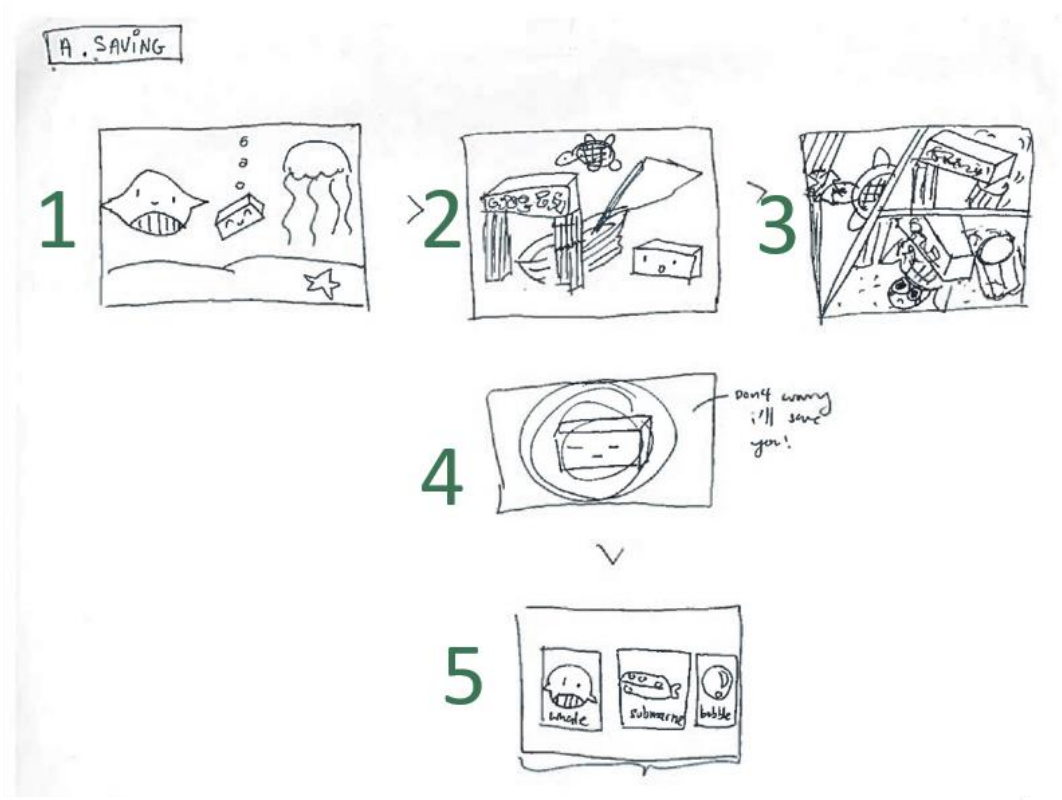

FIGURE 28. SKETCH OF THE 'SAVING MISSION' MINI STORY

Figure 28 shows a sketch of the protagonist helping a fellow sea creature become unstuck for the 'Saving mission'. All of the mini-stories will have the following scene components in order:

1. **Story setting scene:** Introduces the player to the new place the protagonist has travelled to.
2. **Conflict scene:** The protagonist will face a problem.
3. **Transformation scene:** The protagonist will be getting ready to transform as seen in scene 4 of Figure 28.
4. **Options scene:** A menu of available transformation objects for the protagonist to turn into will be shown.
5. **AR scene:** The player will be able to view his/her selected object augmented onto the block he/she will be holding up to the camera.
6. **Celebration scene:** This scene concludes the end of the mini-story whereby the conflict is solved and everything is fine again.

The mini-stories will be designed such that their ordering do not matter. This is so that the overall game story makes sense when the player is able to decide on which places to go next.

4.2.1.2 Character Design

Figure 29 below shows the main protagonist of the story. The shape is a rectangular cuboid which has the same aspect ratio as the wooden block upon which the design will be pasted. All sides of the blocks are augmentable so that the child can turn the block and be able to view the 3D model augmented on it from all sides. The face of the character is designed to be slightly asymmetrical so that the marker detecting software can easily detect it from the camera's feedback. The dimension of the block was chosen because out of the various shapes from the wooden toys set (with wooden semi-spheres, different lengths of cuboids, cylinders, cubes, cones etc.), the shape and size is the most tactile for a child to hold [A3].

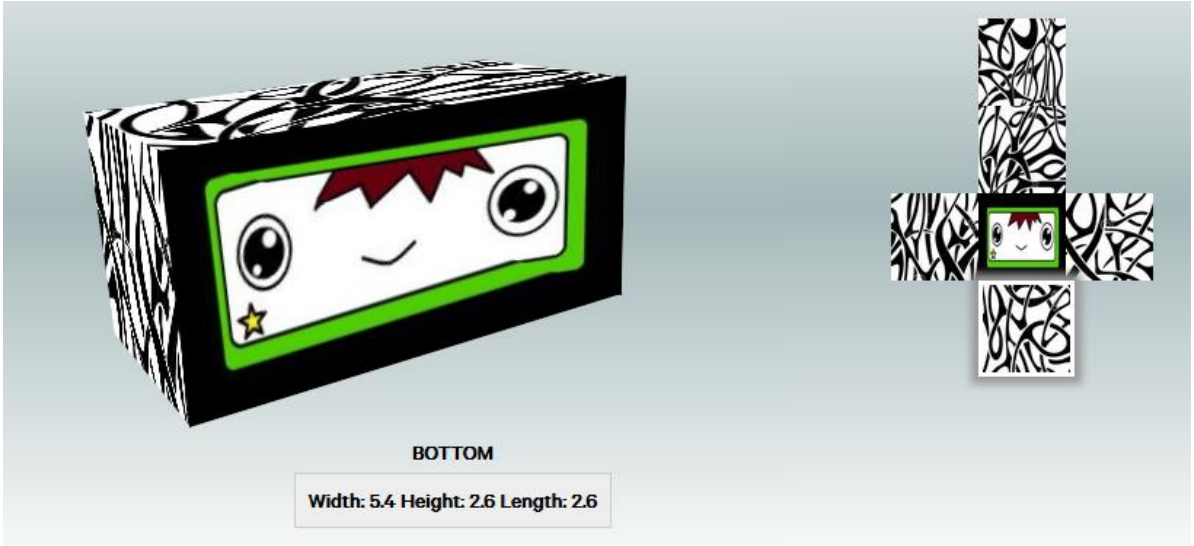

FIGURE 29. GREEN NINJA BLOCK DESIGN

FIGURE 30. SCREENSHOT OF VUFORIA'S TARGET MANAGER PAGE

The augmentation asset used, Vuforia, has an online supportive tool called Target Manager, seen in Figure 30, which allows developers to check for the quality of each marker. It is important for the quality of every markers used to have full augmentability score represented by the stars on the right so that it is easily detectable [A2]. The yellow crosses on the image in Figure 30 shows the features detected by the program. Thus, the patterns on the markers have to be as unique and detailed as possible. This explains the star on the character's face and its messy hair.

FIGURE 31. PASTING THE MARKERS ON THE WOODEN BLOCK

4.2.1.3 Prototype's Menus and Introduction Design

The first part of the game has been developed so that the overall design can be evaluated by the experts in the following section. Their feedback will be used to improve the game's design concept which will be utilised for the rest of the game's development.

4.2.1.3.1 The Menus

The main menu as seen in Figure 32 was designed to be as simple and light as possible with the underlying playfulness theme hearted (yellow colour, Jokerman fonts and winking character) [B1]. Yellow has been found to be the colour most associated with happiness for young children (Zentner, 2001). The menu buttons contain generic icons for 'Play' and 'Settings' actions [C5]. However, the settings button is still under consideration as the typical settings parameters such as volume, brightness and sound (for background music) are adjustable via the Andriod tablet's much simpler interface (swipe down panel which contains settings control). The game will aim to have minimum background noise so that volume or mute controls will not be needed much at all for the user's convenience. Further design decisions will be made after experts' feedback and more development has been made.

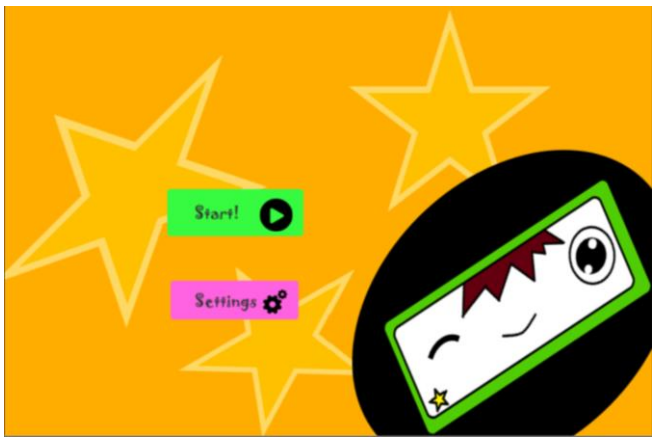

FIGURE 32. MAIN MENU

FIGURE 33. MINI STORIES MENU

Figure 33 shows the mini-stories menu with huge clickable picture panels and coloured borders [C5]. The mute button is included as a cheerful ukulele background music is added

to this scene. Thus, should the player find this music annoying, he/she can turn it off easily [A3]. The music is meant to lift the mood of the child while he/she is deciding which option to pick as it might take a while. The close button on the right-hand corner allows the player to end the game and go back to the main menu. This button, along with the back button (goes to previous scene) will be in almost every scene of the game so that the child can quit the game or undo his/her action anytime [A2].

4.2.1.3.2 The Introduction

As shown in Figure 34, the introduction sets the foundation of the story comprising of the first sequence of scenes all new players are expected to play through so that they know what to do for the rest of the game and what is going on.

FIGURE 34. SCREENSHOTS OF GAME INTRODUCTION SCENES SEQUENCE

Scene 1-3 introduces the wooden block character (yet to be named), Scene 4 is the conflict scene, Scenes 5-6 are the transformation scene, Scenes 7-8 are the AR scene, Scene 9 is the

celebration scene and Scene 10 transitions the player to the mini-stories selection menu. Scene 1-2 shows the animation (pouring green light) used in the game to increase engagement. The transformation scenes contain additional transformation and 'view' button at a new position. This slight change of required user input action is aimed to catch his/her attention and thus, emphasise the transformation (theme of pretend play) of the character. Also, it prepares the player for the transition from the linear experience (storytelling) to the interactive AR experience as suggested by the design guideline [C5]. The poop humour suggested from the workshop was put into the story as the transformation object to deter the dragon [B1].

FIGURE 35. TRANSFORMATION SCENE

Figure 35 shows the design of the transformation scene without the buttons. This scene's entire focus is on the protagonist character and thus, the backdrop is black and a whirlwind animation is added to direct the player's attention [C2].

FIGURE 36. AR SCENE IN ACTION

In Figure 36, the green outline in the AR scene is used to tell the player where to put his/her block. From the design workshop, there was a lot of difficulty experienced by some children when positioning the block. Thus, the outline is added as a guideline for optimum positioning

within the AR scene so that the marker can be detected [A3]. This alleviates the problem of the block being too far away or too close to the tablet's camera. Also, when the app loses track of the marker, the outline will appear again to help the player.

The right scene of Figure 36 shows the change made to the dragon once the marker is detected. The spiral eye would rotate, the green stink from the poop character would be rising up like steam and fiery animation would be dancing like the auroras from the side of the character. These animations serve as dynamic stimuli rewards for the player [C2].

4.3 Expert's Feedback

This section describes the semi-structured interview with usability experts which took place in their respective work places after the planning, the drafting and the development of the low fidelity prototype. Also, the aims, details and results of the interview sessions are discussed.

4.3.1 Aims

The aims of the interview sessions were:

1. To evaluate the appropriateness of the game layout for encouraging pretend play in the target group.
2. To evaluate the usability of the overall design of the game app's main design theme.
3. To evaluate the appropriateness of the game tasks for the target group.
4. To get further ideas for design plan improvements.
5. To confirm preferences for the chosen content that the target group might find interesting.

4.3.2 Participants

TABLE 6. LIST OF EXPERTS IN EVALUATION OF LOW-FIDELITY PROTOTYPE

Expert	Background
E1	Professional usability tester with a background in developing game for children with ASC and teaching children with ASC.
E2	HCI professor who specialises in human factors of security and privacy systems
E3	Adaptive learning environment professor who specialises in developing learning environments for typically developing children and children with ASC
E4	Research postgraduate student researching in pretend play AR app for children with ASC

4.3.3 Materials

The introduction section of the game app was developed on the Samsung Galaxy tablet together with the main menu navigational scene and the mini-stories menu scene. However, the script has not been added to the game app. Also, the marked wooden block and a few 3D

model augmentations were added to the app for viewing purposes. The game structure design sketches were used to show the rest of the game design plans.

4.3.4 Procedure

The interviews were recorded so that summarising notes can be taken afterwards. This action was consented by each expert. Each session lasted for about 40-50 minutes. The experts were presented with the game framework introduced in this chapter via sketches. Then, the introduction of the game app was shown to them together with the marked wooden block. After they have played with the AR scene, their feedback on the game plans was then requested. The researchers were asked to answer a series of questions. The interview questions were centred loosely about the aims to keep the conversations more flexible and open to ideas.

4.3.5 Results

4.3.5.1 Game Layout

All experts did not find any issues with the game framework sketch. E4 mentioned that the layout provides a good environment for learning object substitution via cause and effect events. E2 agreed that play should be something children enjoy and is self-motivated, thus, it is a good decision to apply flexibility in the game with choices. However, the repetition might get boring so changing some game elements is good. E1 recommended emphasising the tangible wooden block being represented in the game so that the children can project the character within the external environment independently.

4.3.5.2 Game app's Introduction Design

Both E2 and E4 suggests that the main menu includes a button for the child to navigate straight to the mini-stories options menu so that he/she can skip the introduction scenes. Also, E4 suggests removing the 'next' button during the storytelling altogether to increase simplicity and focus of the game for young players.

E2 suggests that the 'view' icon on the button circled in Figure 37 be more intuitive. The button transits the story scene to the AR scene and thus, a camcorder icon would be more fitting as it is descriptive of a live camera feed. Also, she recommended positioning the button below the character. This change was subsequently implemented later on as shown in the right-hand side of Figure 37. The behaviour of the button is like before, whereby it will only appear after the player presses the transform button underneath. This is so that the player's action is guided linearly to reduce confusion.

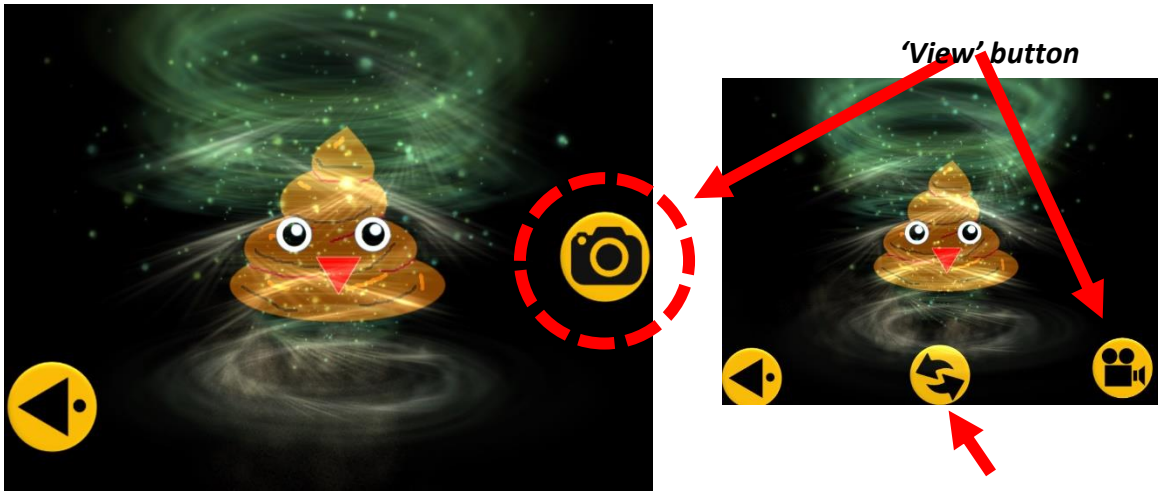

FIGURE 37. TRANSFORMATION SCENE

The transformation scene left most experts slightly confused about when the AR scene would be showed. Thus, the script in this scene should be more detailed to explain what is going on and what the user should do.

In the AR scene, even though the dragon's rolling eye and tongue animation has been added when the marker is detected, E2, E3 and E4 recommended that the AR scene should have more user input response such as a progress bar, sound effect or some sort of animation from the dragon. E1 suggests making the AR scenes timed so that the child will not get stuck in a repetitive behaviour within the scene. E2 suggests taking a screenshot of the AR scene then explain what the children is doing in the following scene with the picture. Overall, the experts seemed agree that the children would want a sense of completion from the AR scene.

FIGURE 38. MINI-STORIES OPTION MENU

All experts agree that the children will understand the story given the visuals and good simple narration. E4 suggests the removal of the sparkling animation in Figure 38 as it would be too distracting to the child (he/she might be transfixed and would try to tap on the sparkles).

4.3.5.3 Game Tasks

E4 suggests playing around with the number of augmentation (transformations) options available to increase the game's complexity or let the children create their own augmentation object in the game as a challenge to test if they have learnt how to create their own pretend play event. Furthermore, she went on to suggest letting the children create their own scene background or cause and effect motions.

4.3.5.4 Further design ideas

E1 recommended exploring social play to improve memorization of skills as the other player can serve as an external reminder of the block's pretence ability in external play conditions (without the app). Both E2 and E4 suggested recording the AR scenes in the form of pictures or video recording (10s) so that the child can replay them and review the whole game story at the end of the game. This can be the shareable component of the game app so that the children can share what they have learnt.

4.3.5.5 Content Preferences

E1 mentioned that children with ASC loves trains, the solar system and anything that rotates such as wheels. This suggestion motivated the script for the second mini-story in space where the protagonist visits the moon. She also suggested that creating more augmentation options would solve the challenge of finding object(s) of interest for a specific child. However, both E3 and E4 emphasised that the children within the spectrum would have a difficult time choosing if too many choices (more than five) are presented.

Both E1 and E4 suggested letting the children take photos of the objects they would want to augment onto the block. Also, E4 emphasised that any animations made should appear natural to the children to increase generalisation and thus, understanding and application of what is learnt. Lastly, both E2 and E3 agreed that having 3D augmentation is a good idea whereby the augmentation model can be viewed from all sides of the marked block.

4.3.6 Discussion

There was a great deal of positive feedback and design ideas from the experts. Most of the design ideas were implemented in the following section. However, there are also a few suggestions that were not implemented. Justification is given for these decisions below:

Unimplemented design suggestions

1. *Timed AR scene*
   Timing the AR scenes would make the game play unnecessarily rigid. Where possible, the game would be open and flexible to emulate the nature of pretend play. Thus, instead, the AR scenes will be given an increased sense of completion but the player will not be forced to move on to the next scene. He/she will be allowed to change the augmentation object and continue playing within the scene.

2. *Creation of augmentation objects, background and, cause and effect motions*[10]

[10] Player is able to determine what the augmentation object will do to other game objects.

Letting the players create their own augmentation objects by taking photos is a great idea. However, the amount of work to apply image pre-processing (cropping object in the foreground from image background by automatically detecting it) is not feasible for the scale of this project.

Other suggested customisable features such as the background and cause and effect motions creator will increase a considerable amount of work to be done without answering the research question. Thus, this suggestion will be added to future work section in the last chapter.

3. *Social play as learning reinforcement*
   The focus of this project is not on social play and as other experts have suggested, there are other ways to reinforce the learning experience of the child (i.e. having a gallery of photos summarising game play). To direct the game into the social play, the game will need a restructuring of its framework whereby cooperation between two players is emphasised. However, the idea will also be covered in future work.

4. *Video recording*
   There is a simpler, faster and less messy alternative to this suggestion which is taking a photos. Although taking a video in each AR scene then stitching the clips into a story at the end of the game is a good idea, the game story as a whole is quite lengthy in comparison to the short AR scenes.

5. *Creating more augmentation options to find child's object of interest*
   From the design guidelines and opinions from other experts, having too many options for a child with ASC can be overwhelming and the process of choosing would be more work than play for the child. The game app instead will be trying to increase the likelihood that the child will find his/her object of interest within the game by using the children's inputs from the design workshop, balancing gender preferences and inserting at least one vehicle object into all sets of augmentation object choices.

4.4 High-Fidelity Prototype Design

The full game is developed and justifications for the final design choices are discussed in this section. Some of the experts' feedbacks, design guidelines and design workshop's results will be used to shape and develop the rest of the game. Changes are made to the low-fidelity introduction part of the game app and narration is added to the game scenes.

4.4.1 Narration Voice

Several online Text-To-Speech (TTS) converter tools were tested to find the most natural sounding voice to optimise players' comprehension [B2]. The digital speaker used was a 'British English' accented middle-aged man's voice. Due to unavoidable imperfect reproduction of speech from the TTS system[11] chosen, the name 'Peter' was used as the game protagonist's name because the TTS system was able to pronounce 'Peter' clearly and

[11] http://www.fromtexttospeech.com

correctly. Care was taken as the name will frequently be mentioned throughout the game so its articulation has to be distinct from other adjacent words in the sentences. All the sentences in the game script were tested and carefully edited to remove incorrect or unnatural pronunciations and unnatural pauses in the sentence. For example, the word 'ninja' was omitted as the digital speaker could not pronounce the word very well. The scripts will be shown in the following section.

4.4.2 Changed Features

As suggested by the experts, the main menu, shown in Figure 39, has been updated with two buttons: 'Options' button to direct the player straight to the mini-stories options menu, and the 'Gallery' button to direct the player to a gallery displaying his/her photos taken during the game as shown in Figure 40. The 'Settings' button was removed as it was not necessary.

FIGURE 39. UPDATED MAIN MENU

The gallery displays the photos in loose chronological order of the game from top left to bottom right. This ordering is based on Sesame Workshop authors' suggestion that a child's flow of attention is usually in the order when scanning a screen (shown by the red arrows in Figure 40) (Sesame Workshop, 2012). The photos not only serve as a shareable reward for the child, they also remind the child the various possibilities pretend play can take from a single wooden block [A1]. By tapping on one image, the image would expand to fit the screen so that the player can have a better look. Tapping on the expanded image again would shrink it back to where it originally was. The photos are taken during the AR scenes in each mini-stories including the introduction. The photos can also be viewed in the tablet's album folder. From there, the photos can be saved somewhere else or shared with assistance from the caretaker of the child. Every time the 'Gallery' button is pressed, the photo files will get overwritten and updated if new ones are taken during the game for each story.

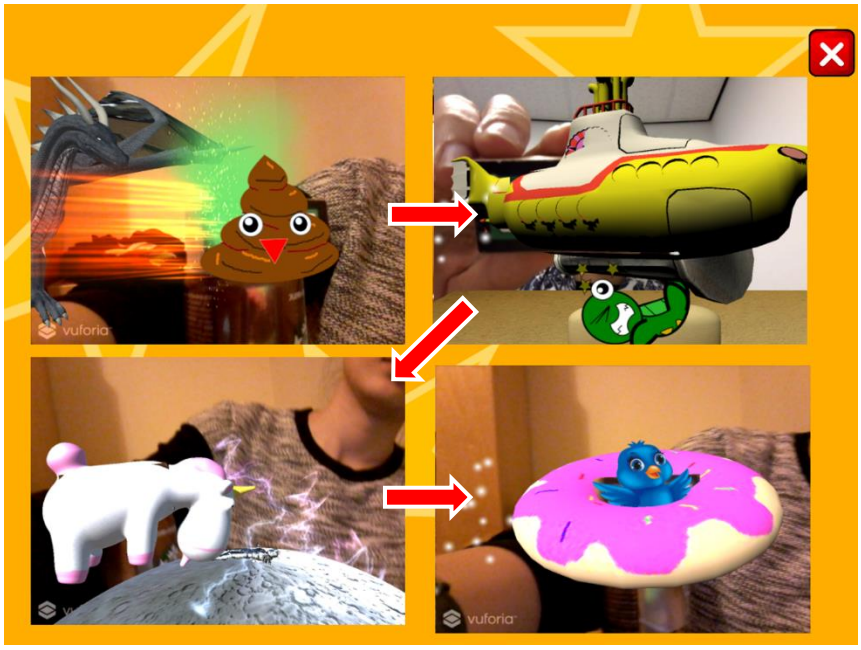

FIGURE 40. GAME'S GALLERY

Also, a progress bar was added to each AR scene, as seen in Figure 41, to address the issue of AR scenes lacking a sense of completion (raised from the experts' feedbacks). The bar also adds a game element to the scene by making the AR task more tangible. After the bar fills up, a photo will be taken with an accompanying shutter sound.

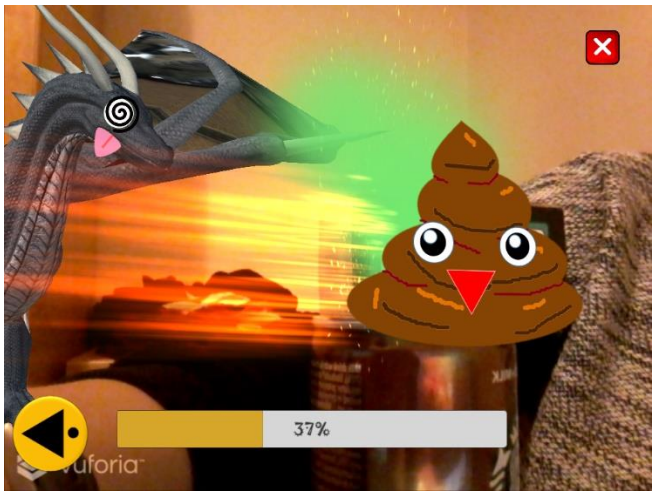

FIGURE 41. SCENE WITH PROGRESS BAR ADDED

The shutter sound's volume was reduced (in relation to other game's sound) so that the sudden unexpected noise will not frighten sound sensitive children. In the mini-stories, the bar is positioned vertically so that it will not obstruct the game objects in the scenes.

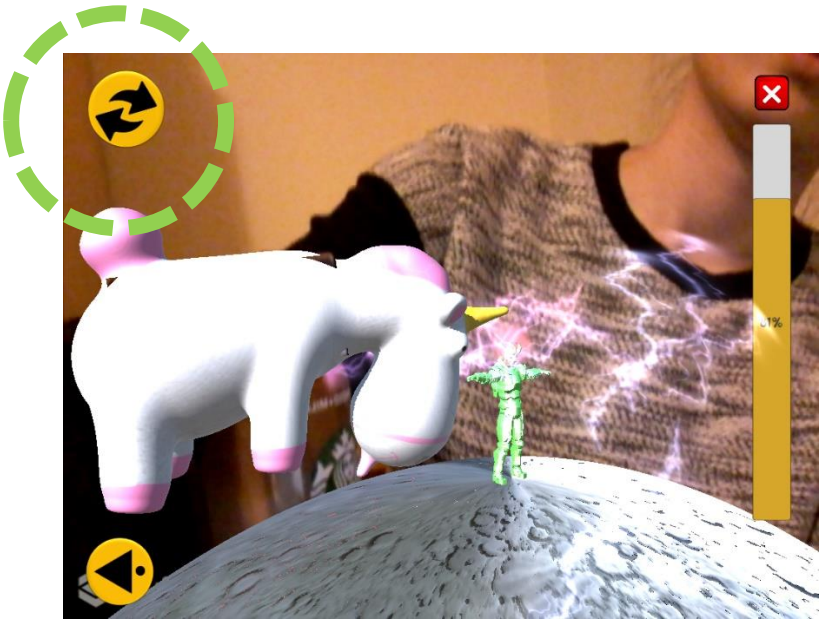

FIGURE 42. AR SCENE IN A MINI STORY

An additional 'Transform' button (circled) is added to the top left side of the screen so that the child can change the transformation whenever he/she wishes. When the button is pressed, an augmentation objects options menu will appear as shown in Figure 43. Tapping on an object option will take the player back to the AR scene.

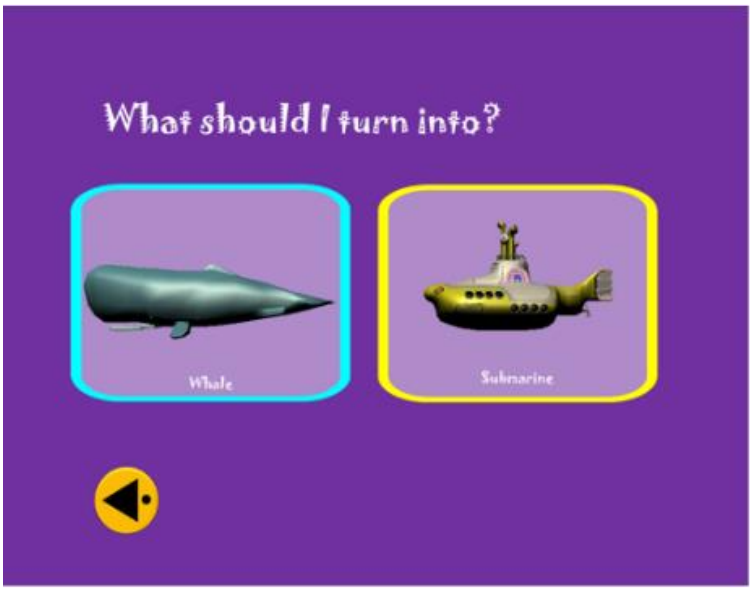

FIGURE 43. EXAMPLE OF AUGMENTATION OPTIONS MENU

4.4.3 Mini-Stories Design

The final scripts are shown in this section as a concise description of what is going to happen in each game scene. The vocabulary and sentences in the narrative scripts are kept short and simple [C2].

4.4.3.1 Introduction Sequence

Each numbered line of the script below represents a new scene in the game. The script for the introduction sequence shown in Figure 34 is as follows:

Intro scene 1: *Once upon a time, there was a magical wooden block named Peter. Every year, it would wake up from its sleep to explore the world and go on adventures.*

Intro scene 2: *The special day has finally arrived. Peter was excited. He created a magical portal. The portal would take him anywhere but sometimes, Peter could not control where he ends up.*

Conflict scene 1: *This time, he ended up in a dragon's den and the dragon was very angry.*

Transform scene*: Peter has to escape! He closed his eyes to get ready to transform into a stinky poop. Press the button below to help Peter.*

>> *Now, press the view button to see Peter in your hand!*

AR scene 1: *Now, hold Peter up to the screen so that he fits into the green box.*

AR scene 2*: Well done! You have helped Peter make the dragon dizzy from his stinky smell! Your photo is now saved and can be viewed in the main menu.*

Ending scene 1*: The dragon flew away and Peter is safe. He is so happy he did his little dance.*

Ending scene 2: *After a while, Peter's portal starts to light up again. It seems to be working properly now. He wonders which place he should visit this time.*

Mini-stories Options Menu: *Click on the place you would want Peter to go to. Under the sea, on the moon or in a garden?*

As shown from the script above, the narrated instructions when important, are placed at the end of the sentence so that the child will understand why he/she is doing an action before performing it [C6]. In **AR scene 2**, the line is accompanied by a screenshot of the player holding up the block with the augmentation. The purpose of this design decision is to make it explicit to the child what he/she has done by retelling what has happened as a result of his/her actions. This was implemented because of an expert's comment on making AR events clearer by not just relying on animations to tell the story. Additionally, because the experts showed uncertainty in the pre-AR scene where they have to click on the 'Transform' button, more care is taken to instruct the players on what to do in the scene (**Transform scene**). The word 'Now' is used to direct the children's attention to the present situation so that the subsequent instruction becomes clearer [C2]. The verbal positive feedback, 'Well done!', is used to praise the child for performing the right action after the AR scene [B3].

4.4.3.2 Saving mission Sequence

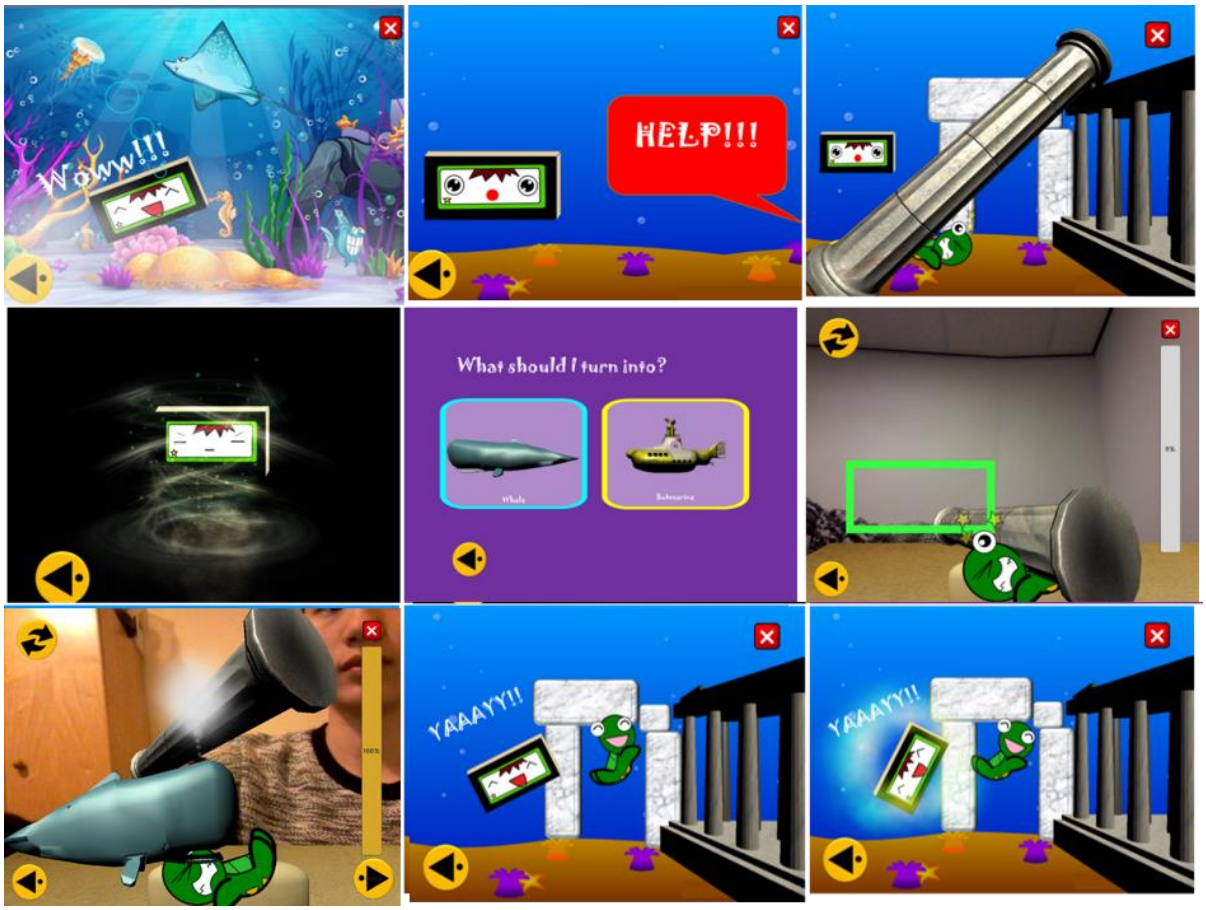

FIGURE 44. SCENE SEQUENCE FOR 'SAVING MISSION'. (SCENE(S) DUPLICATED TO SHOW ANIMATION EFFECTS)

This mini-story, Figure 44, drew inspiration from the children's underwater temple idea in the design workshop. It is about Peter helping a fellow sea creature become unstuck for the 'Saving mission'. The script is as follows:

Intro scene 1*: The sea floor was beautiful. Peter became friends with the fishes, the stingray and the seahorse and played with them for a while.*

Intro scene 2*: Soon after, he continued to explore the sea floor because he was still curious. Suddenly, he heard a cry for help.*

Conflict scene*: A sea turtle was stuck underneath a fallen pillar. "Please help me push this pillar!", said the turtle. "I'm stuck!"*

Transform scene*: Peter closed his eyes to get ready to transform.*

AR scene 1*: Choose an object Peter can transform into so that he can lift the pillar.*

AR scene 2*: Well done! Press on the next button to go to the next scene or press on the transform button to continue playing.*

Ending scene*: The turtle is now free. They were both happy and they started to dance. Peter's portal lighted up again after a while so he said goodbye to his new friend.*

As seen from the AR scenes in Figure 44, the 3D model of a pillar floats up with a stone crumbling sound effect when the app detects the marker but floats down when the marker is not detected. This increases the responsiveness of the game to the user's input actions as recommended by the experts.

4.4.3.3 Fighting mission Sequence

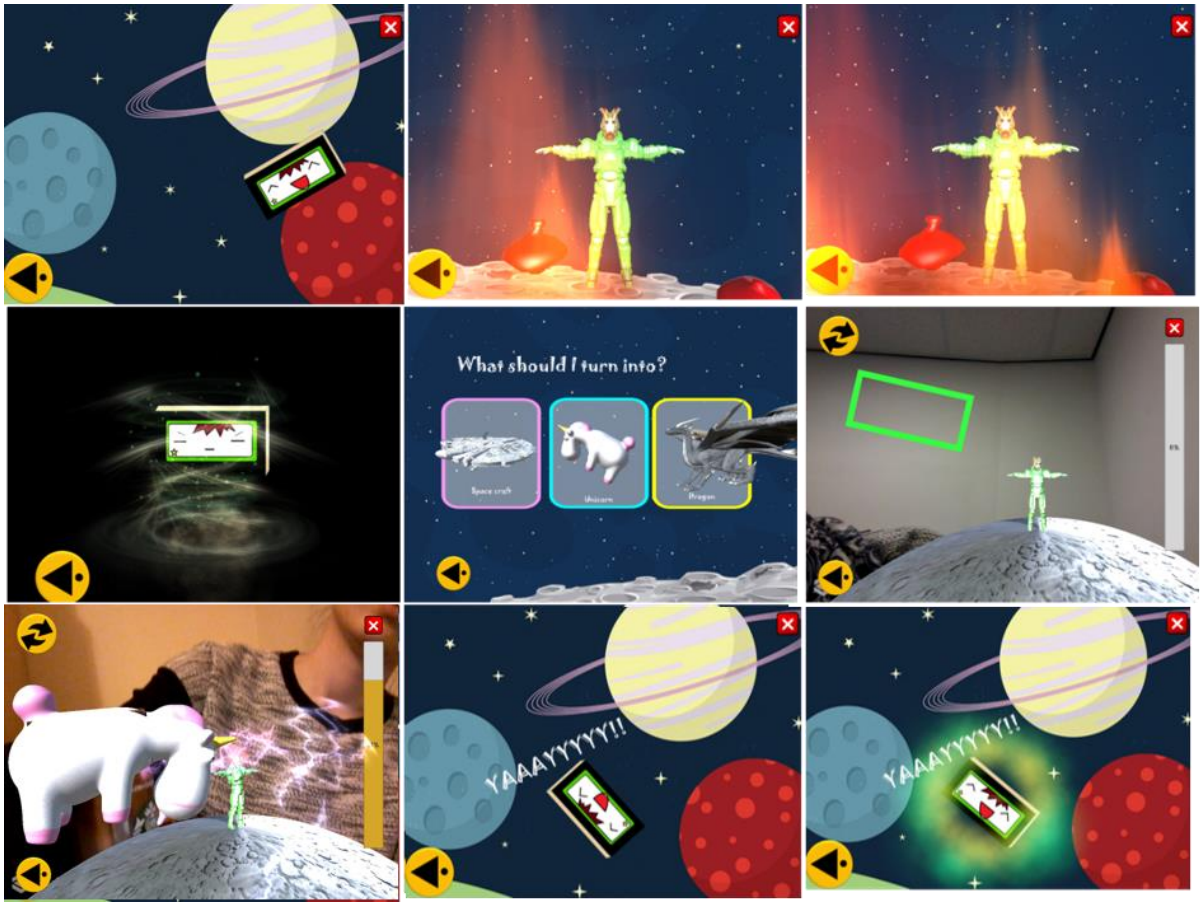

FIGURE 45. SCENE SEQUENCE FOR 'FIGHTING MISSION'. (SCENE(S) DUPLICATED TO SHOW ANIMATION EFFECTS)

This mini-story, Figure 45, drew inspiration from the children's exploding moon and evil robot ideas in the design workshop. It is about Peter attacking an evil alien to save the moon for the 'Fighting mission'. The script is as follows:

Intro scene*: Peter was very excited to be in space because he can fly. Suddenly, he heard explosions behind him.*

Conflict scene*: As he got closer, he found a green alien on a moon. "I'm going to blow up this whole place!" said the alien. With a lift of his arms, he started to destroy the rocks.*

Transform scene*: Peter closed his eyes to get ready to transform.*

AR scene*: Choose an object Peter can transform into so that he can stop the bad alien.*

20: The alien lost the fight. Peter has saved the moon. He did his little dance and the portal lighted up again.

The user actions feedback in the AR scene are the 'mechanical crying' sound effect coming from the alien, the animation of the alien turning and the animations coming out of the

objects being augmented on to the block. The unicorn, as shown in Figure 45, shoots lighting out of its horns while the space craft shoots out fiery rays and the dragon shoots out fireballs as shown in Figure 46 below.

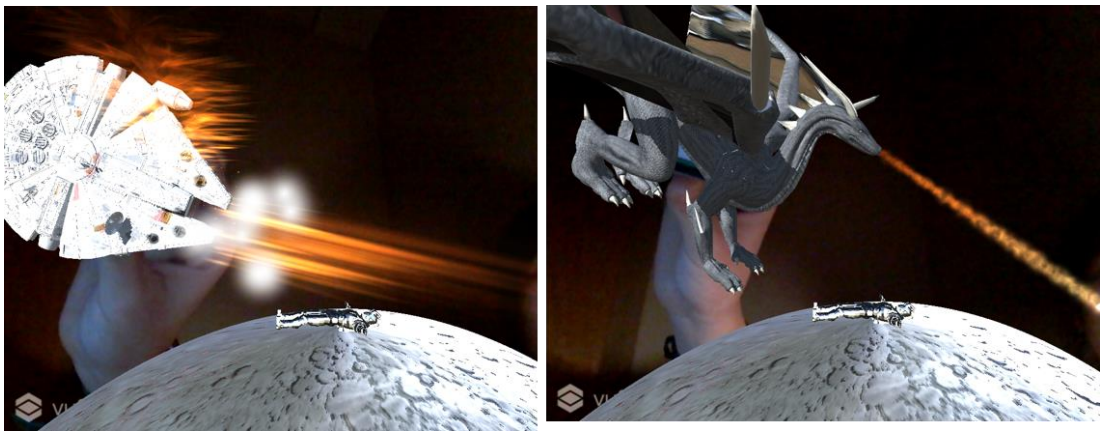

FIGURE 46. ATTACK ANIMATIONS FOR THE AUGMENTED OBJECTS

4.4.3.4 Adventure mission Sequence

FIGURE 47. SCENE SEQUENCE FOR 'ADVENTURE MISSION'. (SCENE(S) DUPLICATED TO SHOW ANIMATION EFFECTS)

This mini-story, Figure 47, drew inspiration from the children's garden party and saving a baby bird ideas in the design workshop. It is about Peter traveling with a baby bird in order to return it back to its nest for the 'Adventure mission'. The script is as follows:

***Intro scene**: Peter landed on a flower in the garden. It was really pretty. He was amazed.*

***Conflict scene**: When he got down on the ground, he found a baby bird crying. He asked her why she was crying. She said she was blown out of her nest and could not fly back to her nest.*

***Conflict scene**: Peter closed his eyes to get ready to transform.*

***Transform scene**: Choose an object Peter can transform into so that he can carry the baby bird back to her nest.*

***Ending scene**: Peter has carried the baby bird back to her nest! She thanked him and they said their goodbyes. Then, Peter lighted up his portal and was off on his way.*

The user actions feedback for the AR scenes is the tweeting sound effect of the bird and the movement of the grass below it as the app detects the marker. The baby bird character is added to the augmented objects as shown in Figure 48 to illustrate the idea of the object 'carrying' the baby bird. The particle effect animation and the smoke from the train model is used as dynamic stimuli reward.

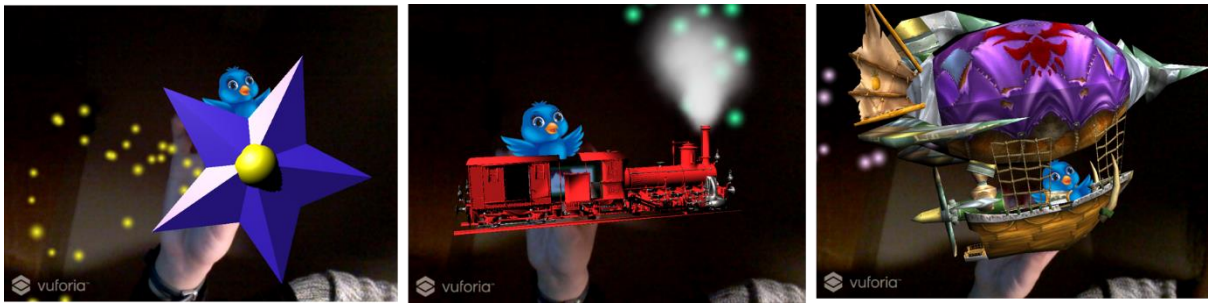

FIGURE 48. DIFFERENT AUGMENTATION CHOICES TO CARRY THE BIRD

4.4.4 Augmentation Options

As seen in Figure 49, the number of choices increases in the game assuming a child picks out the mini-stories in the order from left to right (sea-> space-> garden). This idea was suggested by one of the experts during the feedback in order to vary the game's complexity for young children. Also, to avoid gender bias present in earlier research (Bai, et al, 2015), the game augmentation choices and stories took into consideration the sexes of the children so that the game app would be appealing to both girls and boys. By increasing the varieties of game objects available, the likelihood of the child finding his/her object of interest also increases. Most of the object choices were inspired from the design workshop. However, it is to be noted that this is just a generalising assumption and that children will have overlapping preferences.

TABLE 7. GENDER THEMED AR OBJECT CLASSIFICATION

Scene	Girl oriented theme	Boy oriented theme
Sea (unisex)	Whale	Submarine
Space (boy oriented)	Dragon, Spacecraft	Unicorn
Garden (girl oriented)	Donut, Star	Train, Spaceship

Moreover, as vehicles is a favourite theme for most children with ASC, the submarine, space craft and train were added to each level so that some of them can always have an option they would be interested in. Even though it is expected that some of the children would choose a particular transformation, the other options act as support to give them the illusion of choice. This helps to increase interest and thus, engagement within the game. Moreover, it encourages exploration in pretend play behaviour should the child replays the stage and chooses a different transformation object.

FIGURE 49. AUGMENTATION CHOICES THROUGH THE STORIES

As suggested by the design workshop, a food themed donut was added to the choice mix in the last mini-story as a comic relief, a positive mood inducer or at the very least, an object of curiosity for children with ASC. The fact that donuts cannot fly might challenge the belief of most children and if they chose it, they are going a step further in pretend play by giving the donut a non-existent superpower.

4.5 Pilot Testing

4.5.1 Aim

The aim of the pilot testing session was to:

1. Identify gross bugs, missing features, and lack of interaction within the game app.
2. Test for failure in the game's narration audio output to bring the story across.
3. Identify any other additional requirements and changes needed in preparation for the formal evaluation workshop in the next chapter.
4. Get suggestions for improvements from the young children's perspectives.

4.5.2 Participants

The test was conducted over 2 sessions with 3 girls (1st Group) and then 4 girls (2nd Group) aged 8 to 10 (no siblings) in a games hall. All participants' literacy levels were sufficient to understand instructions and express themselves.

TABLE 8. PILOT TEST PARTICIPANTS

Pilot Test Workshop			
Child	**Sex**	**Age**	**Siblings**
1st Group			
S1	F	9	
S2	F	8	
S3	F	8	
2nd Group			
S4	F	10	
S5	F	8	
S6	F	8	
S7	F	8	

4.5.3 Materials

The game app was installed onto a tablet (Samsung Galaxy Tab A). An information sheet was given to the parents to explain the study, its aims and the procedure (see Appendix B). A consent form was also handed out to the parents to get their consent (see Appendix D). A child consent form was also produced (see Appendix A). A phone was used to audio record the session. After the parents, had been provided with the information sheet and the consent form, formal consent was gained. The children were also given explanations about what they were going to be asked to do and were ensured that they were not obliged to participate and could withdraw from the observation at any point in time. Then, the children were asked to sign the child consent form.

4.5.4 Procedure

After the parents, had been provided with the information sheet and the consent form, formal consent was gained. The children were also given explanations about what they were going to be asked to do and were ensured that they were not obliged to participate and could withdraw from the observation at any point in time (see Appendix C). Then, the children were asked to sign the child consent form.

The group of children were shown the game app and guided to the game's introduction sequence. After that, they were free to navigate through the game however they like. Their reactions were observed. A laptop in which also runs the game app in the Unity Engine was used as a backup. After 15 minutes, the children were asked if they liked the game and the story in general and what improvements they would like to make to the session.

4.5.5 Results

4.5.5.1 User Behaviour

Improvements and changes to be made for the formal evaluation session is noted down in the additional requirements section below.

- Both groups of girls navigated to the 'Garden story' first out of other mini-stories. Both groups of girls also picked out the donut first from the garden story, unicorn from the space story and the whale from the sea story before experimenting with other objects. This suggests that the assumption made about gender preferences for certain objects is supported.
- Very few clicked on the 'Transform button' to replay the AR scene with a different augmentable object. However, the group replayed the same story a few times to change the object instead so that they can get different photos in the gallery with different poses.
- Both groups liked the gallery features and were able to navigate to it easily.
- Both groups enjoyed the game graphics and the story in general. However, due to the noisy environment, most of the girls could not hear the audio sound clearly.
- Due to low lighting condition, there was some difficulty trying to get the marker detected especially on the laptop. Thus, this left a few children disinterested after failing to get the block detected for a while.
- Two girls were frightened by the dragon in the introduction scene. This may be due to the roaring sound it makes. To make the dragon less scary, the volume of its roaring sound was reduced.
- Both groups only played with the augmentation in a 2D space without rotating the block to see other sides of the 3D augmentation object. Thus, marking the whole block seemed unnecessary. The patterned markings on the sides of the block were removed.
- Four children requested for a choice of having a female protagonist in the game after they were shown another design made for the wooden block seen on the left of Figure 50. Also, five of them wanted it to be a multiplayer game. These are good ideas and thus, will be put in the future work section.
- A girl suggested changing the label of the main menu's button from 'Options' to 'Places' because it was confusing. This change was later implemented.

FIGURE 50. MARKED WOODEN BLOCK FINAL DESIGN

4.5.5.2 Game App Fixes

- The story scenes would have one to two second lag before moving on to the next scene after the narration audio has ended because each scene has been set a fixed number of seconds (i.e. 10s) before it would be changed. However, the children became very impatient with the wait and would try to tap the screen to get the scene to change.
  - Fix: The scene changing behaviour was changed to make it more responsive to the audio clips ending so that there is less lag.

- In the garden mini-story stage, the game app would stop working during the AR scene even though it runs perfectly fine on the laptop. The children were directed to the game on the laptop instead to complete the rest of the scenes for the story before resuming on the tablet.
  - Fix: The bug was removed afterwards so that the game does not crash on the tablet.

4.5.5.3 Additional Workshop requirement(s)

- The group of children were a bit impatient when waiting for a child to finish playing with the block. Thus, two augmentable blocks will be shared within the groups for the formal test workshop.
- All children should be able to hear the narration clearly and thus, a quiet testing environment is a necessity.
- Bright testing environment is also necessary for the markers to be easily detected.

FIGURE 51. CHILDREN TESTING OUT THE GAME PROTOTYPE

Chapter 5

Evaluation

5.1 Evaluation with Children

5.1.1 Aims

The aims of this study were to:

1. Determine the play experience for young children.
2. Determine the likeability of the game for young children.
3. Determine the comprehensibility of the game story from the technical aspect (clarity of generated voice clips to young children) and the story aspect.
4. Identify further usability problems in the application.
5. Get suggestions for improvements from young children's perspectives.

5.1.2 Participants

The test was conducted over 3 sessions with 3 girls and then 4 boys aged <> in a comfortable, quiet and bright environment. All participants' literacy levels were sufficient to understand instructions and express themselves.

TABLE 9. EVALUATION WORKSHOP PARTICIPANTS

Evaluation Workshop			
Child	**Sex**	**Age**	**Siblings**
1st Group			
S1	F	11	
S2	F	12	
2nd Group			
S3	M	9	Yes
S4	M	7	
S5	M	8	
3rd Group			
S8	F	5	Yes
S9	M	5	

5.1.3 Materials

The updated game app was installed onto a tablet (Samsung Galaxy Tab A). An information sheet was given to the parents to explain the study, its aims and the procedure (see Appendix D). A consent form was also handed out to the parents to get their consent (see Appendix B). A child consent form was also produced (see Appendix A). A phone was used to audio record the session.

Two augmentable wooden block characters were used for each session so that more than one child can play with them at the same time. Also a child survey was made to test their response towards the app (see Appendix E). The Fun Toolkit, which is a method to gather opinions in child computer interaction, was also included as seen in Figure 52 (Read & MacFarlane, 2006).

FIGURE 52. FUN TOOLKIT QUESTION IN SURVEY

Additionally, as shown in Figure 53a comprehension multiple choice question (MCQ) test was written to test the children's understanding of the game's storyline (see Appendix F). This is because the children understanding the context to why augmentations have to be conjured in the AR scenes is very crucial to the project.

2. Why did Peter turn into a stinky poop?
    a. He wanted to make the dragon laugh.
    b. He wanted to poison the dragon.
    c. He wanted to chase the dragon away.
    d. I don't know.

3. Why did Peter attack the green alien?
    a. The alien was trying to destroy the moon.
    b. The alien was attacking Peter.
    c. The alien was ugly.
    d. I don't know.

4. Why did Peter turn into a whale/submarine?
    a. So that he can explore the sea floor.
    b. So that he can crush the pillar.
    c. So that he can lift the heavy pillar.
    d. I don't know.

FIGURE 53. EXAMPLES OF MCQ COMPREHENSION TESTQ

5.1.4 Procedure

After the parents, had been provided with the information sheet and the consent form, formal consent was gained. The children were also given explanations about what they were going to be asked to do and were ensured that they were not obliged to participate and could withdraw from the observation at any point in time (see Appendix C). Then, the children were asked to sign the child consent form.

The groups of children were shown the game app and guided to the game's introduction sequence. After that, they were free to navigate through the game however they like. Their

reactions were observed. A laptop which also runs the game app in the Unity Engine was used as a backup. After playing with the game (about 15 to 20 minutes), the children were given the survey and the comprehension test to complete. After the documents have been collected, they were asked if there were improvements they would like to make to the game. The second part of the workshop took around 10 minutes.

However, due to time constraints, the last workshop was cut short whereby the children were only able to play one stage of the game before assessing it, thus, they did not do the comprehension test.

5.1.5 Results

5.1.5.1 Survey

Question: How much do you like the game app?

None of the children voted for 'Awful', 'Not very good' or 'Good'. This suggests that they liked the game app and that it is successful in attracting their interests.

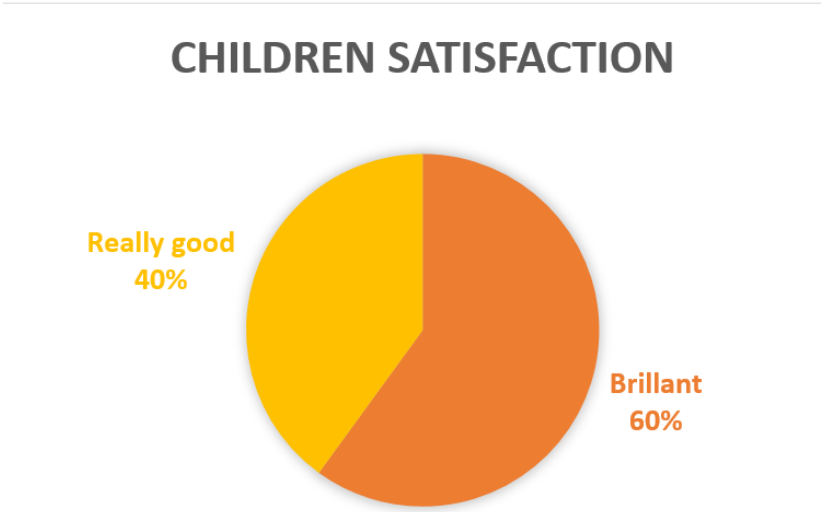

FIGURE 54. RESULTS FROM FUN TOOLKIT QUESTION

Question: Do you think the app was fun to use?

All the children voted for '*Yes*'. This implies that there were no major usability issues (i.e. frequent time lags or difficulty in AR marker detection from pilot test) that would cause the children to not enjoy the game.

Question: One thing you liked about the game?

Children's written answers:

- *The scenes*
- *The different choices.*
- *It's fun. (Interpreted from 'Yay')*
- *The pictures. (Game's graphics)*
- *The stinky poop.*
- *That he could see his photos afterwards.*
- *The transform button.*
- *Everything*

The different aspects of design choices were supported by their positive feedbacks. The 'transform button' comment refers to the fact that the child is able to replay the scene and choose another augmentation object he/she would like Peter to turn into.

Question: One thing you don't like about the game?

Most children left the field blank or wrote 'I don't know' or 'Nothing'. The rest of them answered:

- *Lack of levels*
  The age of the TD child who commented was 11 year-old. Thus, the game was too simplistic for children her age.
- *More expression in the narrator*
- *The options*
  The child who commented only completed the sea scene which only has two options.

Question: Which scene was your favourite?

Most voted for the garden scene while one boy voted for the moon scene. One girl voted for all the scenes except the sea scene. This result may be due to the higher number of choices in the AR scene as the TD children would be more biased towards more complex task.

Question: Did you like the sounds?

All the children voted for '*Yes*'.

Question: Was there any sound that you did not like or that was annoying?

Most children left the field blank except for one boy who commented that he disliked the sound that the alien makes when he was attacked. Consequently, the sound effect's volume for the high pitched audio clip was reduced. Overall, the children seemed to generally like the sound effects in the game.

5.1.5.2 Story Comprehension Test

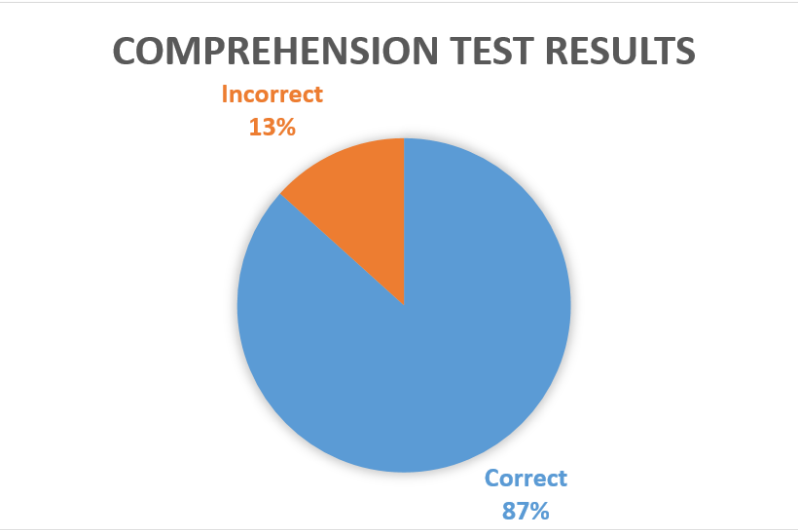

FIGURE 55. NUMBER OF INCORRECTLY OR CORRECTLY ANSWERED QUESTIONS FROM MCQ TEST

As shown by Figure 55, most of the children were able to answer most of the questions correctly. All of the questions were answered correctly by the children except for two of the following:

1. Question: How is Peter traveling from place to place? (Magic portal)

Incorrect answer(s):

- *By flying.*
- *By creating a hurricane.*

The incorrect answers may incorrectly be inferred from Peter flying with the baby bird or the whirlwind of dust animation that occurs in every 'Transform scene'. This suggests that these children did not listen to the part of the narration which pointed out several times that Peter has created a 'portal' to travel while an animation of a portal would appear. As audio support is not as effective as visual or action support to promote comprehension (suggested by the Sesame Workshop design guideline earlier), it would be a good idea to get the player to help Peter create a portal themselves (i.e. by manoeuvring the wooden block in a circular motion with accompanying sound effects) to emphasise this aspect of the story. However due to time constraints, this mini-story cannot be developed.

2. Question: Why did Peter turn into a stinky poop? (To chase the dragon away)

Incorrect answer(s):

- *He wanted to poison the dragon.*

The animations of the dragon may be a bit misleading to this child. Thus, moving the dragon away (backing away in the scene) in response to the amount of completion of the progress bar would be a good idea.

The children were able to get the rest of the MCQ questions correct. This means that they understood:

- Why Peter attacked the green alien.
- Why Peter turned into a whale/submarine.
- Why Peter was carrying the baby bird.

These aspects of the story are essential to the game play as the children are carrying out pretend play actions to solve the problem created by the storyline. This may also be the reason why they were able to get these questions right; because they carried out the necessary play action and thus, reinforced the concepts in their minds. Thus, this suggests that the game app was successful in communicating to the child the essential storyline which enhances pretend play.

Additional comment: A boy was fooling around, remarking "I know it's the wrong answer but no one cares." while completing the test. Thus, his comprehension test result i.e. Figure 56, was not taken into consideration.

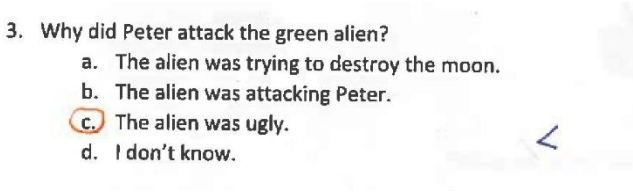
3. Why did Peter attack the green alien?
   a. The alien was trying to destroy the moon.
   b. The alien was attacking Peter.
   c. The alien was ugly.
   d. I don't know.

FIGURE 56. FAULTY DATA

5.1.5.3 Further Improvements Suggested

1. Narrator's voice too robotic.
   - This fault can easily be improved by purchasing better TTS systems or selecting the purchasable (more natural sounding child voices) from the chosen TTS source to convert the script dialogues. However, within the scope of this project, the children were able to understand the spoken words which were selected based on how well each word (within each line) sounded when produced by the chosen TTS.

2. Sound effect for the train augmentation object.
   - This missing detail was left unimplemented because there is already a sound effect of the baby bird tweeting while on the train in the AR scene.

3. Multiplayer fighting action game.
   - This idea can encourage social play for children with ASC. However, it is not the aim of the project. Thus, it is put in the future work section.

4. Scrollable gallery without photo updates so that old photos are also kept.
   - So far, the gallery is kept with the static structure to summarise the game's story in a simple way. However, it might be a good idea to be able to view previously taken photos for each AR scene once that image of that scene was selected from the gallery in a pop-up window with a scrolling bar as illustrated on the right side of Figure 57. However, due to time constraints, it was unimplemented.

FIGURE 57. GALLERY IDEA

5. More events in each mini-story.
   - This is implementable, however, as this game was meant to be kept simple with predictable story structure for young children with ASC, having a complex storyline may not be a good idea.

6. Narration of the word 'moon' in the mini-stories option menu was not clear.
   - The word has been changed to 'space' which the TTS system was could pronunciate better. Thus, now the line becomes "*Click on the place you would want Peter to go to. Under the sea, in space or in a garden?*"

7. The picture representing the garden in the mini-stories option menu was ambiguous.
   - The picture has been changed to the garden scene.

8. Add a hide and seek mini game in the narrated scenes to find and collect augmentable objects for the AR scene.
   - Although this is a very good idea, it does not align with the project's objectives. Also, it makes the game more complex. Thus, it is not implemented.

9. Let the game have customisable printouts of the wooden block character designs.
   - This is a good feature for allowing the children to personalise their own 'Peter' character. However, this would require an adult assistance and thus, is put into the future work section.

10. Use 'stickers'- drag and drop of basic shapes to allow the player to build his own augmentable objects.
    - This is a good suggestion but is not implemented due to time constraints. Thus, it is tagged as future work.

11. Give the game a name: '*Peter's Adventures'.* This detail was overlooked.
    - The name was given to the game app and now, heads the main menu.

5.1.5.4 User Behaviour

FIGURE 58. A BOY PRETENDING TO EAT THE POOP DURING THE AR SCENE. (ALSO A FORM OF PRETEND PLAY)

- As seen in Figure 58, the children would pose for the pictures after finding out about the gallery which was also what the girls from the pilot test would do. They would naturally engage in self-initiated pretend play and create their own scenarios to make their photos interesting.

- There were a few instances where the child would press on the 'Close' button as circled in Figure 59 which takes them back to the main menu. However, they actually wanted to go back to the gallery itself which can be done via tapping on the enlarged image again. This shows that the tap design is not intuitive enough when combined with the close button and hence, the close button is removed when the image is expanded. Furthermore, it was discovered that the 'Back' button in the augmentation objects options menu was redundant as tapping on any object brings the player back to the AR scene. Thus, that button was removed too.

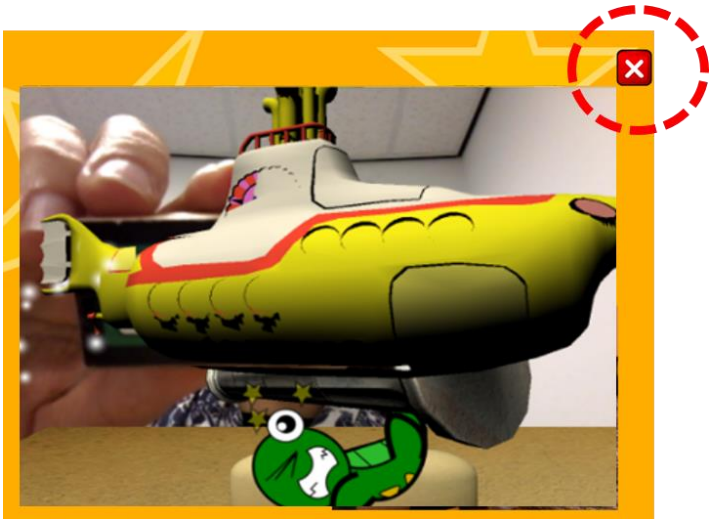

FIGURE 59. EXPANDED IMAGE IN GALLERY

- In the introduction's transformation scene, the 'View' button seemed unfamiliar to the children as they took a while before figuring out that they should press the button. Thus, the icon was changed from a camcorder to an eye as it directly translates to the word 'view' as shown in Figure 60.

- The children would immediately press on the 'Next' button in the AR scene after the progress bar has filled up and the instruction was narrated halfway: "*Well done! Press on the next button <<**child presses next button**>> to go to the next scene or press on the transform button to continue playing.*" This is most likely because the children followed the first command that was said and did not have the patience to listen to the rest of it. Thus, the instruction was edited to: "*Well done! Press on the transform button to continue playing or the next button to go to the next scene.*"

FIGURE 60. CHANGED VIEW BUTTON

- One child exclaimed the "story makes sense!" This observation points out the significance of the logical ordering of a story even though it takes place in a fantastical setting.

5.1.6 Summary

In conclusion, the game generally has good levels of usability and user satisfaction for young children tested. The design choices made earlier were supported by the children's list of the favourite things they liked about the game (i.e. different choices and re-playable AR scenes). One child did not like the robotic pronunciation of the narrator. It was also noted that any change in 'complexity' by increasing options will most likely not affect TD children as the game is meant for children with lower cognitive skills. Thus, this may be why most preferred the last scene with four augmentation object options.

The sound effects of the game in general is good. However, it is to be noted that some children with ASC are especially sensitive to sound and thus, may find some particular sound annoying. Thus, the conclusion may not apply to the target user. From the pilot test and this evaluation, the volume of some sound effect has been adjusted to suit some child's preference (i.e. the dragon's roar or the alien's noise). Hence, making each sound effect's volume adjustable by clicking on a setting button available on each game scene would be a nice implementation. However, due to time constraints, this feature is not implemented.

The comprehension test revealed that some animations did not portray a clear meaning or that more details has to be added to the game play. However, the children were able to grasp the basic storyline that goes into each playable AR scene.

Respective adjustments to the game have been made and justifications for unimplemented ideas were explained (above). Interestingly, the children started to engage in pretend play to get a better photo in the gallery and one child pointed out the importance of the logical ordering of the storyline which has not been included as a design requirement.

5.2 Evaluation with Experts

This section describes the semi-structured interview with usability experts which took place in their respective work places with the high-fidelity prototype. Also, the aims, details and results of the interview sessions are discussed.

5.3.1 Aims

The aim of the interview session was to:

- Evaluate the instructional soundness of the game.
- Evaluate the appropriateness of the game features for children with ASC who have little to no pretend play skills.
- Evaluate the potential of skills generalisation.
- Identify any usability problems in the game design.
- Get suggestions for improvements.

5.3.2 Participants

As shown in Table 10, two of the same experts who participated in the low-fidelity prototype interviews also participated in this evaluation session.

TABLE 10. LIST OF EXPERTS IN EVALUATION OF HIGH-FIDELITY PROTOTYPE

Expert	Background
E1	Professional usability tester with a background in developing game for children with ASC and teaching children with ASC
E2	HCI professor who specialises in human factors of security and privacy systems
E4	Research postgraduate student researching in pretend play AR app for children with ASC

5.3.3 Materials

The game app installed onto a tablet (Samsung Galaxy Tab A) was used to show the game app together with the wooden block. For E4, a headphone was provided (to listen to the game sounds and narrations) as the interview was held in a common area. A phone was used to record the interview.

5.3.4 Procedure

The interviews were recorded so that summarising notes could be taken afterwards. This action was consented by each expert. Each session lasted for about 40-50 minutes. The experts were presented with the game app installed on the tablet after which they were able to play through the game however they like. If they have missed any part of the game, they would be informed of the part. After they have played through the whole game, their feedback was then requested. The researchers were then asked to answer a series of questions. The semi-structured interview questions were centred loosely about the aims to keep the conversations more open-ended.

5.3.5 Results

5.3.5.1 Game Effectiveness

Both E1 and E4 seemed to like the game and agreed that the game was very good for teaching children with ASC how to pretend play. E1 commented that the game does this by expanding the children's imagination through the fun stories and AR objects and thus, the game serves the purpose of initiating pretend play. Furthermore, she liked how the game has a constant focus on the wooden block character (i.e. the transformation scene where the character was against the black backdrop) because this increases generalisation of the play; when the child no longer engages with the game app, he/she would still be able to remember the wooden block character in his/her hand and play with it outside of the game app context.

Moreover, E1 also commented that the gallery was good for increasing the memorability of the wooden block character and its functionality to the players by reinforcing the relationship they have had with it in the game. E4 on the other hand, likes the game's repetitive framework where there is a constant cause and effect structure to emphasise the impact of pretend play.

5.3.5.2 Game Features

Both E1 and E4 commented that the story and augmentation objects options are suitable for children with ASC. E1 commented that the adventure was nice and the resulted gallery of photos provides the child with fun memories of the game. She also pointed out that the sound effects were good. E4 however noted that the voiceover was 'too strong' and thus, having a child voice narrator would be better. Better yet, she suggested letting the types of narrators' voices be selectable by the player.

E2 found an inconsistency at the beginning of the game where the 'magical wooden block' would become 'awake' 'every year'. She recommends editing the lines of the script to make it clearer what the abilities of the block are as children who pays particular attention to these kinds of details might get annoyed. Also, she recommended add an extra detail during the garden AR scene so that the player would know that he/she has reached the nest at the end of the scene.

E2 went on to comment that the instructional narration was good overall as it guides the user exactly to what he/she has to do so that he/she will not get lost in the game. Finally, she mentioned that she likes the simple choices given within the game although she would have liked the game objects to be more interactable (i.e. the augmentation being able to physical push the 3D pillar model)

Both E1 and E4 mentioned that after the AR scene has been played and the 'Transform' button was pressed, the progress bar should be able to reset itself along with other game objects that were changed.

5.3.5.3 Overall Usability

E4 suggested that the 'Close' buttons in the mini-stories scenes be directed to the mini-stories options menu rather than the main game menu.

E4 did not realise her photos of her were being taken during the game and was surprised to discover the gallery filled with her photos. Thus, she suggested making the photo taking more

obvious by having a shutter sound be played. However, as it was already playing at low volume (not heard clearly), increasing the volume would be a good idea.

All of the experts were clicking on the question mark on the mini-stories options menu circled in Figure 61. They seemed to think that it was a button when it is just used to illustrate the thought of Peter deciding where to go next. However, the children from the pilot test and test workshop did not notice it. Thus, no changes were made to this feature as the question mark was not visually loud (compared to big colourful buttons) and the unexpected behaviour was most likely due to the experts' keen eyes for details.

FIGURE 61. QUESTION MARK ON MINI STORIES OPTIONS MENU

5.3.5.4 Further Improvements

E4 suggests increasing complexity of the play by allowing any common objects (i.e. household items) to be augmentable not just the wooden block. She then explained that the children can be taught how to put these objects together to create their own pretend play scenarios. This can also be used as a challenge in the game to test what they have learnt about pretend play. E1 suggest social play utilising AR tools as the next step forward because it tackles other issues that children with ASC has.

5.3.6 Conclusion

The experts were positive about the potential effects of the application on children with ASC. They felt that the repetitiveness and consistency of the story was put to good use to teach children with ASC how to engage in pretend play. The game features such as the story and gallery were good. However, some aspects of the story at the beginning could have been better explained. Additional further improvements that can be implemented were adjusted according:

- Increasing shutter sound effect volume when taking pictures
- Directing 'close' button in the mini-stories scenes to the mini-stories option menu
- Editing the garden AR scene so that Peter and the baby bird reach a tree at the end as shown in Figure 62.

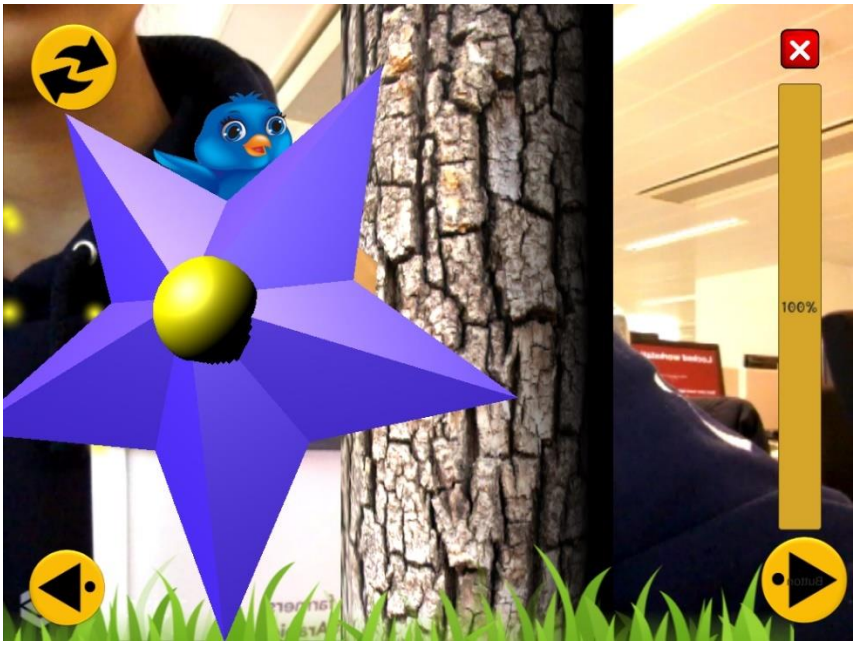

FIGURE 62. EDITED GARDEN AR SCENE

The rest of the changes were not implemented due to time constraints:

- Editing the beginning part of the storyline so that Peter's powers are clearer
- Making game objects more interactable
- Resetting the progress bar
- Allow a variety of narration voices to be chosen from

Overall, the evaluations sessions have been generally positive. However, due to the limited resources and feasibility, the real user group (children with ASC) could not evaluate the game app. Hence, it should be noted that the results is not totally reflective of the intended outcome.

CHAPTER 6

CONCLUSION

The first section of this chapter is focused on answering the research questions that were presented in Chapter 2 by discussing the results from the evaluation studies with the experts and children. The second section discusses possible directions for future work.

6.1 CONCLUSION

The present research investigated how to design a story-based AR game tablet app to support children with ASC learning how to pretend play. Taking into account the limitation of time, the research was specifically focused on how the theories, related researches and different design principles can be represented in a game for children with ASC. The approach was highly participatory with TD children and experts from ASC, HCI and education backgrounds. The overall methodology has followed the framework of a cooperative inquiry design process as described in Chapter 2.5. The final game app has been through a number of iterations of prototyping and game design, getting feedbacks from experts and typically developing (TD) children. The research attempted to answer the main question, **'***How to design a game that encourages children with ASC to pretend play?',* which has lead the subsequent research questions which will be answered in the following section. The verdicts, however, are based on a huge assumption that the TD children and experts' opinions are representative of and are giving reflective opinions about the targeted user. Thus, a lot more research needs to be done to generalise the verdicts on the overall target population.

6.1.1 USABILITY

Research question: Is the AR game appropriate for children with ASC?

INTERFACE AND AR HANDLING

From observations, the TD children did not find any major usability issues with the game and were able to navigate through it easily. From the survey, the children found the game 'fun to use'. Any minor details that were overlooked were fixed (i.e. the expanded image view in the gallery with the misleading close button).

In low light condition, the app tend to lose track of the marker, thus, having the optimal environment to support the AR system is necessary as the children would become impatient when the AR detection is not working properly. This can thus, also be frustrating for children with ASC.

STORY UNDERSTANDING

The TD children understood most of the story, especially the events occurring during the AR scenes. Thus, the language used, visual support and sound effects were appropriate to help the children comprehend what is going on although more animations could have been used to explain Peter's abilities. This detail was pointed out by an expert and a comprehension test question. Overall, the experts agreed that children with ASC will most likely know what is going on within the game and that the structuring of the mini-stories and the focus on the

protagonist Peter allows for predictability and consistency which some children with ASC may enjoy.

Game Instruction and Narration Voice

The TD children were able to follow through the game with ease and a HCI expert pointed out that all player actions within the game has been carefully guided by the narrator such that they player would always know what to do.

One major aspect of narration that could have been improved was the quality of the narration voice from the TTS system. Thus, a few narration audio versions of the game is recommended by an expert (as the game is heavily based on the narrator) so that children with ASC who have particular preference for a certain type of voice can have a choice.

Verdict

Given the evaluation results, the AR game is most likely appropriate for children with ASC.

6.1.2 Satisfaction

Research question: Will the target group in general find the AR game fun and engaging?

The experts are positive that children with ASC will most likely enjoy the choices given (one expert mentioned that they were 'fun') and the gallery feature which also serves as a shareable reward. Also, a few feedbacks from the TD children evaluation showed that they liked the game's graphics, scenes, choices, humour, photos and the re-playable AR scenes. Al

Verdict

Given the evaluation results, the target group will most likely find the AR game fun and engaging.

6.1.3 Utility

Research question: Will the AR game be effective in encouraging and supporting pretend play behaviours in children with ASC?

The experts agreed that the game was very good for teaching children with ASC how to pretend play by expanding the children's imagination through the fun stories and AR objects. Furthermore, the constant focus on the wooden block character was said to have the potential to increase generalisation of the play by allowing the child to remember how to play with it externally in reality (independent of the game app).

Moreover, one expert mentioned that the gallery was good for increasing the memorability of the wooden block character and its functionality to the players by reinforcing the relationship they have had with it in the game. Also, another expert pointed out that the game's repetitive framework where there is a constant cause and effect structure to emphasise the impact of pretend action could potentially teach the child how to engage in pretend play.

VERDICT

Given the evaluation results, the AR game will most likely be encouraging and supporting pretend play behaviours in children with ASC.

6.1.4 DISCUSSION

Overall, it is still difficult to conclude whether children with ASC will find the game intrinsically motivating (user satisfaction) and if they will eventually learn how to apply what was taught in the game: symbolic thoughts via object transformations in order to initiate own pretend play (utility). Further research needs to be made in this area for more conclusive results.

Moreover, as the target users did not participate in the game's design, particular requirements that may be overlooked by the experts may have been missed. Thus, having more experts to review and evaluate the game is a good idea for future work. However, overall, the final game app has the potential to elicit pretend play for children with ASC.

6.2 FUTURE WORK

A major area of future work would be to run the evaluation workshop on children with ASC and evaluate the impact and effectiveness of several main design decisions on helping them engage in pretend play (i.e. choice making and story structure). It may also be interesting to run a long-term study to investigate if the game application will encourage more spontaneous pretend play behaviours from children with ASC at home.

Additionally, several suggestions for improvement were made during the evaluation workshop and the expert evaluation interviews. The two main themes are customisation and social play.

6.2.1 CUSTOMISATION

Letting the scenes (background), animations and the game's protagonist be customisable are good ideas to reinforce the creativeness of the game play. Moreover, letting the children make their own augmentation objects by:

- Using 'stickers' which are basic shapes with customisable colours (i.e. squares, rectangles, circles) to drag and drop on to a canvas.
- Putting any common household objects or toys in front of the AR camera so that it can 'turn' it into an augmentable object (Feasible via Vuforia) and combining them to create pretend play scenarios.
- Letting the player take pictures of the object he would like to transform into a playable augmentation object.

6.2.2 SOCIAL PLAY

The application does not currently support social play. However, by increasing the interactability of the augmentable game objects, the game can also address the difficulties in social development for children with ASC via multi-player cooperation games or fighting action game whereby a two players can pit their augmentation objects against one another.

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APPENDIX A

CHILD CONSENT FORM

To be used as a guide for securing consent or refusal, after the child has had a chance to get information about the study. The child may mark (or be helped to mark) this form, or the child's consent/refusal may be video-recorded.

I can choose to be a games/web developer.

I do not have to help if I don't want to.

I can decide to stop participating or take a break.

I do not have to say why.

It is OK if I change my mind later, and say I do not want to be a games/web developer any more.

It is OK if some parts of the game are hard for me!

There are no wrong answers to questions.

Anything I can do is helpful.

Do you want to be a games/web developer ? **YES ☐ NO☐**

Orisa and Helen will listen/watch to the recording later.

They will show it to other people who make games for children.

Is it OK to take an audio/video record? **YES ☐ NO☐**

Write your name: _____

THANK YOU!

APPENDIX B

PARENT CONSENT FORM

	Please circle
Have you read the information sheets?	YES / NO
Have you received enough information about the study?	YES / NO
Do you understand that participation is completely voluntary and your child can leave the study at any time, without having to give a reason?	YES / NO

Please sign this page to indicate that you understand and accept the conditions of this study, including audio and video recording. By signing, you agree that the researchers may explain the study to your child and invite him or her to take part as a game/web designer.

With reference to further anonymous use of photographic,audio or video data, please circle yes or no in response to the following:

I AGREE that short videos/images of my child can be used as examples in documents and presentations for research and/or teaching purposes.

YES / NO

If you give permission for this study, please return this form to the researchers.

If you DO NOT wish to give permission, you do not need to return this page. We will not ask your child to participate.

Full name of participating child:

Child's date of birth (DD/MM/YYYY): _____/_____/_____

Your relationship to the child:

Your name (please print clearly):

Contact telephone number: _____

E-mail address: _____

Best time and method to reach you?

Signature:

Date: _____ /_____/_____

APPENDIX C

CHILD INFORMATION SHEET

New computer games/websites to help children

(to be read aloud to the child)

This page is for children. It is about some people who are organising an **event at University of edinburgh**. It says who they are, and what they will do **during the event**.

The organisers will ask for your help. You can help by playing a new computer game, **participating in different activities**,listening to some music and answering a few questions. You can decide if you want to say "yes" or "no" to helping,and change your mind at any time.

The researchers on this project and their contact details are as follows:

Ms. Orisa Ngampakdeepanich, lead researcher(s1309783@sms.ed.ac.uk; 07895863725)

Prof. Helen Pain, research advisor (helen@inf.ed.ac.uk)

Who is organising the event? This is Orisa and Helen. Their job is to learn about how children use computers, and how to make computer games and websites that can help children. They will ask you to help them by playing a new computer game, participating in different activities**,** listening to some music and answering a few questions.

Helen

Orisa

Why are we organising this event ?

To solve the problem some children face when trying to engage in pretend play, Orisa and Helen will be creating a game to encourage children to become more motivated to be imaginative and creative during their play time. By becoming our game designer, you will be trying out an augmented reality tablet application and designing new character objects for the design of the game.

What is the computer game?

The game is about expanding your creativity and imagination while you are playing with your toys. To play the game, you will be using the game application on a tablet or a phone to see "augmented reality". What is augmented reality? Augmented reality is the result of adding a digital layer of animation objects onto the real world. It can change the way we see the environment around us through our cameras.

In this workshop, the camera will be using certain pictures to detect where to put the augmented reality objects on. You will be using your creativity to play with blocks of different shapes in two augmented reality scenes. It is alright if you don't have many ideas, it's all about having fun.

What will happen if I help? They will prepare a workshop at the University of Edinburgh. When you arrive, you will be told more information and then you will go to one of the areas that will be set up. There, you will get to play with game prototypes, take part in design workshops and and participate in other activities. There, you will get to play with a game prototype, and participate in other activities.

You can tell Helen or one of the researchers if you want to stop doing any of the activities playing the with the game prototype,not answer a question or not participate in an activity. You do not have to tell them why. Please tell them if you need the toilet, or if you want to take a break. You can also say you do not want to be a game developer any more, and that is OK. They will always listen to you.

The researchers will ask if it is OK to make an audio recording of you playing the game, and answering questions. This is because it is too hard for them to write down everything that happens. They will listen to the recording later to help them understand what you said, and what happened when you played the game.

What will happen after I am finished helping? They will learn a lot about children and computers from the things you make, do and say when you play with the games, take part in the design workshops and do other activities. when they watch you play the with the prototype, and participate in other activities. After all the children have finished playing with the prototype and participating in activities, the workshop will be over. they will take the prototype away. They will listen to the recordings of children playing with the prototype, taking part in the design workshops and doing other activities. They will write about what they have learned. Sometimes they will show people recordings of children taking part in the different activities. playing or talking about the game.

Your mum or dad said it is OK for you to help us.

Do you want to be a games developer? You can say “yes” or “no”. It is OK to say “no”. It will not hurt the researchers’ feelings.

Do you want to ask a question about being a games developer? It is OK to have more questions. You can ask them as many questions as you want about being a game developer. Ask your mum or dad to help you call them on the phone or write an email with your question.

APPENDIX D

PARENT INFORMATION SHEET

Designing tablet game for children with ASC: research project

Information sheet for parents and guardians

This information sheet is for parents and guardians explains a research project at the University of Edinburgh, in which we would like your child to participate. It gives information about the project in the form of questions you might have and their answers. If you have further questions, we are happy to discuss them and give you more information.

The researchers on this project and their contact details are as follows:

Ms. Orisa Ngampakdeepanich, lead researcher(s1309783@sms.ed.ac.uk; 07895863725)

Prof. Helen Pain, research advisor (helen@inf.ed.ac.uk)

University of Edinburgh, School of Informatics

Informatics Forum

10 Crichton Street

Edinburgh

EH8 9AB

Please return the parent consent form to one of the researchers if you give permission for your child to participate in the project.

An overview of this project, and how you can help

What is the research project goal?

Lack of imagination has been identified as one of the main ASC symptoms characteristics. Specifically, pretend play is a significant diagnostic indicator of childhood autism and is closely related to critical developments such as symbolic thinking, language and social interaction. Moreover, pretend play is also linked to the ability to understand other's mind. To encourage more spontaneous pretend play in children with ASC, we will be incorporating augmented reality into a tablet game to expand their imagination and creativity.

Why are we doing the workshop project?

The aim of my workshop is to be find out how the children will engage with object props combined with augmented reality from a tablet. The amount of pretend play as a result of different augmented objects being introduced will be measured for the testing. Also, the object design and play of the game can be improved from the ideas suggested from the children.

How can my child help?

To improve conditions and features of an augmented reality application game environment so that the children will be more inspired to pretend play, I will be trying to discover factors in pretend play that ignites a child's imagination and his/her enthusiasm to play. By interacting with the augmented reality system and designing the object/characters, your child will be helping me gain insight and ideas from a user's perspective for the game development stage later on in the research project.

What happens during a workshop session? We will always spend some time before the workshop session to talk to the children, in order to get to know them better and allow them to get to know us, with the aim to make them more comfortable. At an agreed time, we will walk your child from the main area to a quiet place where a particular workshop stand will be set up. Your child will get to participate in a design workshop, play with the prototype or participate in related activities for 15-20 minutes, as well as participate in other activities, or until they want to stop (whichever is first). If your child is willing to talk to us about the activities, we will ask them a few questions.

Video recording: We would like to video record the session, to provide a record for later analysis and allow us to freely interact with your child during the session without worrying about taking notes. If you prefer that we do not use videos or pictures of your child for publications, presentations or teaching purposes, you can indicate this on the permission form. In that case, the video would be seen only by us during the analysis. If you're not comfortable with your child being videoed at all, then your child should not participate in this particular study.

Additional study information

Will this project teach my child new skills? This project is not a type of therapy or intervention. We will not be teaching children new skills or improving existing skills. The information we learn from this project may be used in future games/websites that could help children with ASC.

What happens when the project is over? After the study has finished and we have analysed the information we collected, it will be used to evaluate and further develop the design of the game/website and eventually be presented in a final report. This report along with the data and recordings may be shared or presented in scientific journals or conferences. We never share children's names, schools or other personal information.

How will personal information be protected? Confidentiality is extremely important to us. Recordings and other information (such as forms with children's names) will be stored safely on password-protected computers or in locked cabinets. Access will be limited to the people involved in the research (listed above). Recordings and other information will be identified only by participant codes or pseudonyms, and will be separated from identifying information (such as name or birth date).

Can I have a copy of the games? The game prototypes your child would play with in this study are research software and is designed to help answer specific questions. They do not have the same type of functionality, amount of content, or style of documentation that you may expect from commercial games. However, once the study is over the games may be made publicly available online, for free unlimited use. If so we will send you a link and instructions for installation.

Who paid for this research? This study is part of the undergraduate work for the main researchers (listed above). It is indirectly paid for by the University of Edinburgh and the funding is not attached to a specific project or to any outcomes of that project. Conducting this research brings no financial benefit to the researchers or to the university.

Would you like to participate?

We ask parents to read this information sheet so you can decide whether you think it is a good idea for your child to participate as a games tester.

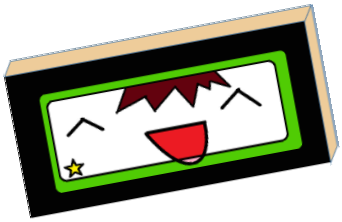
If you say "yes" when returning the permission form, we will then explain the game developer role to your child, and ask him/her if he/she wants to help. We will remind your child that they can stop being a developer at any time, without having to give any reason, and that we will always listen to them. We will check that the child agrees to be audio recorded. This explanation will be based on the child information sheet included in this packet. We feel strongly that children should be given a real choice about whether to participate. Even if you say "yes" on the permission form, your child may still say "no" if s/he does not want to be a game developer. We will respect your child's decision.

If you say "no", we will not contact you again about this study and will not speak to your child about being a games/web designer.

Once again, this study is *completely voluntary* and you and your child are under no obligation to take part. Even if you say yes now, you may withdraw your child from the study *at any time and for any reason* by contacting us. Your child may also withdraw at any time by saying that s/he does not want to be a game developer any more.

Thank you for taking the time to read this.

If you would like to know more about this research and/or if you have questions, please contact one of the main researchers listed above.



APPENDIX E

CHILD GAME TESTER SURVEY

1. How much do you like the game app? (Circle answer)

Awful Not very good Good Really good Brillant!

2. Do you think the app was fun to use? (Circle answer)

YES

NO

3. One thing you like about the game?

_____

4. One thing you don't like about the game?

_____

5. Which scene was your favourite? (Circle answer)

DRAGON SEA MOON GARDEN

6. Did you like the sounds?

YES

NO

Was there any sound that you did not like or that was annoying?

APPENDIX F

CHILD GAME TESTER COMPREHENSION TEST

Circle your answer:

1. Why was Peter carrying the baby bird?
    a. He was playing with the baby bird.
    b. He was helping the baby bird.
    c. He was teaching the baby bird how to fly.
    d. I don't know.

2. Why did Peter turn into a stinky poop?
    a. He wanted to make the dragon laugh.
    b. He wanted to poison the dragon.
    c. He wanted to chase the dragon away.
    d. I don't know.

3. Why did Peter attack the green alien?
    a. The alien was trying to destroy the moon.
    b. The alien was attacking Peter.
    c. The alien was ugly.
    d. I don't know.

4. Why did Peter turn into a whale/submarine?
    a. So that he can explore the sea floor.
    b. So that he can crush the pillar.
    c. So that he can lift the heavy pillar.
    d. I don't know.

5. How is Peter travelling from place to place?
    a. By using a magical portal.
    b. By flying.
    c. By creating a hurricane.
    d. I don't know.

THE END

WELL DONE!

Project Art Graphics Sources

Sites are all accessed on January-February 2017

All models, animations and graphics are loyalty free.

Game Object	Uploaders	Weblink
3D Dragon model	3dhaupt	http://tf3dm.com/3d-model/black-dragon-rigged-and-game-ready-92023.html
3D Spacecraft model	Glenn Campbell	http://tf3dm.com/3d-model/millenium-falcon-82947.html
3D Spaceship model	T3D	https://3dexport.com/free-3dmodel-zeplin-130610.htm
Garden scene	PABLO	http://www.fansshare.com/gallery/photos/16502155/simba-cartoon-wallpaper/
Baby bird	Clipart Fest	https://clipartfest.com/categories/view/69c37b33af91193a0b347278423965c191721013/baby-bird-clipart.html
3D Donut model	tomi901	https://www.turbosquid.com/FullPreview/Index.cfm/ID/542504
3D Alien model	Sam_stunner	https://www.turbosquid.com/FullPreview/Index.cfm/ID/563529
3D Submarine model	rovingmind	https://www.turbosquid.com/FullPreview/Index.cfm/ID/337234
3D Whale model	butterbr0t	https://www.turbosquid.com/FullPreview/Index.cfm/ID/556132
3D Unicorn model	Brady Ewig	http://www.123dapp.com/Search/unicorn/content/all

Tree Bark	~OddGoo-Stock	https://www.pinterest.com/pin/463870830340287242/
3D Rose model	yaschan	https://www.turbosquid.com/FullPreview/Index.cfm/ID/777691
3D Acropolis model	choly kurd	https://www.turbosquid.com/FullPreview/Index.cfm/ID/610885
3D Bridge model	Elena_Shvets	https://www.turbosquid.com/FullPreview/Index.cfm/ID/789884
3D Train model	Locomotive_works	https://www.turbosquid.com/FullPreview/Index.cfm/ID/782987