Developing Educational Games for Teaching Children with ASC

GuessMe: A multiplayer AR game app to elicit pretend play via peer support 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 objects 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 children enjoy co-creating social and imaginary worlds within which they learn how to socialize and play while transforming their understanding of the world, this study aims to introduce the aspect of pretence for the child with ASC through peer support with a typically developing child on an educational game app. Augmented reality (AR) systems which are able to visually conceptualise the representation of pretence will also be integrated to enhance the initial steps a child with ASC takes into pretend play. 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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CONTENTS

CHAPTER 1

INTRODUCTION

1.1 PRETEND PLAY IN CHILDREN WITH ASC[1]

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).

Moreover, in play with peers, children co-create social and imaginary worlds within which they learn how to socialize and play while transforming their understanding of the skills, values, and knowledge of society and culture at large (Corsaro, 1992) (Corsaro & Rizzo, 1988) (Mouritsen, 1998) (Selmer-Olsen, 1993) (Wolfberg, et al., 1999) (Wolfberg, 2009). Integrated Play Groups (IPG) intervention, also known as guided participation, supports both novice and expert players by allowing them to initiate and incorporate the desired activity into socially coordinated play. Hence, it challenges novice players to practice new and increasingly complex forms of play (Wolfberg, 2012). For children with ASC (novice players), IPGs try to foster each child's development and his/her motivation to play, socialise and form meaningful relationships with their peers. For TD children (expert players), IPGs place the emphasis on acceptance and the need to respond to children with ASC (Wolfberg, et al., 2012). In this way,

[1] Some materials from my 2017 MInf 1 project, Peter's Adventures: A tablet app to elicit pretend play for Children with ASC

novice and expert players can mediate their own play activities with minimal adult guidance (Wolfberg, 2012).

This research investigates how a two-player AR game tablet app with TD peer support 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 with his/her peer. 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 with their TD peer.

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

1.2 Previous Work

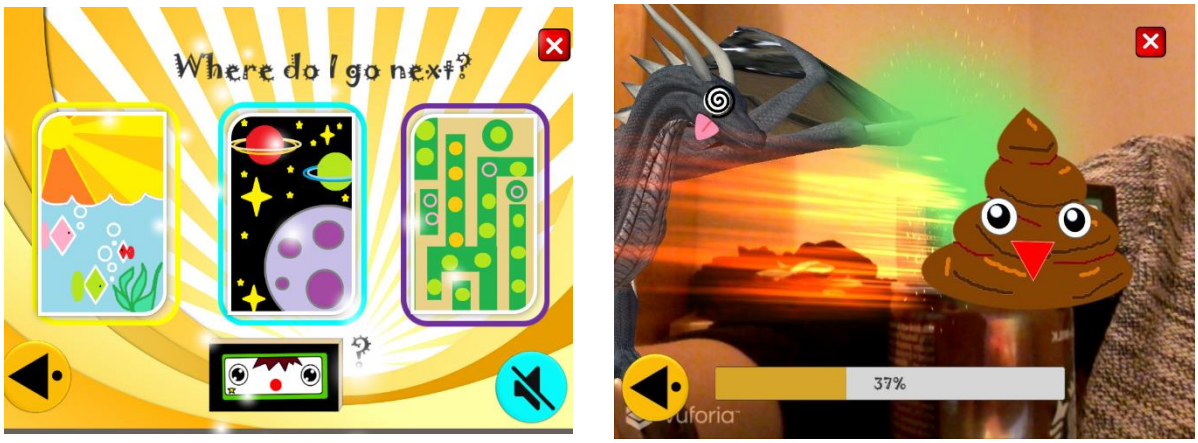

FIGURE 1. PETER'S ADVENTURES SCREENSHOTS

My previous research's aim was to elicit pretend play for children with ASC using a narrative-based AR game app (Figure 1). A wooden block was marked and became a tangible object of transformation through augmented reality in tablet game app called Peter's Adventures. Through freedom of choice, creation of need for pretence, structured learning environment and inclusion of objects of interest, the resulting game was reviewed positively by TD children and experts during the evaluation stage of the study. A Participatory Design approach consisting of typically developing children and experts was used to design, develop and evaluate the app. The results indicated that Peter's Adventures can be used as an educational aid to support pretend play in children with ASC.

Materials taken from the research will be referenced in the footnote of each section title in this paper. My research into eliciting pretend play for children with ASC has been extended on in this paper by involving TD peer support techniques to encourage collaborative social play

so that children with ASC can learn pretend play skills from their TD peers. Thus, this involves researching on justifications and existing methods used in peer support for children with ASC, designing the game to support children with ASC's interaction with their TD peers while ensuring that their TD peers are also engaged with the game.

The aim of this paper is, thus, to create a pretend play educational game app which provides a structured environment for the children with ASC and his/her TD peer to play in with as little support from adults as possible. It will also be encouraging peer support by guiding the social interaction between the players via rules and common goals amongst other game design elements.

1.3 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 and their TD peers?

2. Will the target groups 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?

1.4 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.

Chapter 3: The chapter directs the consequent research development via the subsequent discussion of research question and methodology used. It also 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 may or will affect their game play experience), what exactly is pretend play and its benefits for children with ASC. Moreover, existing methods used to elicit pretend play for children with ASC, how peer intervention with typically developing (TD) children supports learning and how children with ASC interact with digital game applications and augmented reality technology are discussed. Lastly, the methodology used in this research is explained.

2.1 Autism[2]

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

[2] From my 2017 MInf 1 project, Peter's Adventures: A tablet app to elicit pretend play for Children with ASC

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, 1986). This impairment in interpreting 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, many 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).

2.2 Social Interaction

According to Shores, social interaction is a reciprocal process in which children effectively initiate and respond to social stimuli presented by their peers (Shores, 1987). Children with ASC have been observed to have difficulty in this area due to unawareness of their peers, or having an awkward or ineffective social initiation (Kasari, et al., 2012) (Wing & Gould, 1979)

Through trying to cultivate constructive social interaction amongst children with challenging behaviours[3] and their TD peers (4 year-old), a study found a reciprocal effect of positive social behaviour in which after training one child to initiate interaction, untrained peers also increased their initiations for social interaction (Strain, et al. , 1976). Moreover, this reciprocal effect increased by two-fold when both children are trained (Strain, Shores, & Kerr, 1976). Training includes (Strain, et al, 1976):

1. *Physical prompts:* Moving a child to where other children are playing or moving a child's hands, feet, etc. so that he engages in some ongoing interaction with peers.
2. *Verbal prompts*: Prompt the child with comments such as "Let's play with your friends", "You can play this game together" or "Now it's time to play on the slide with Karen"

Hence, this suggests that with the right 'training', young children with ASC and their TD peers can have an increasingly positive interaction over time.

2.2.1 Integrated Play Groups Model

Peer-play experiences are important to children's socialisation, development, and culture. However, as children with ASC face distinct challenges in social and imaginary play, they are more likely to be excluded by peers (Wolfberg,et al. , 2012). Hence, the Integrated Play Groups (IPG) model was developed and evolved over two decades of research and practice to support children with ASC (aged 3 to 11) by engaging them in social and imaginary play with TD peers and siblings in regular social settings (Wolfberg, et al., 2012).

In play with peers, children co-create social and imaginary worlds within which they learn how to socialize and play while transforming their understanding of the skills, values, and knowledge of society and culture at large (Corsaro, 1992) (Corsaro & Rizzo, 1988) (Mouritsen, 1998) (Selmer-Olsen, 1993) (Wolfberg, et al., 1999) (Wolfberg, 2009). Hence, peers support the play of children with ASC in ways that cannot be duplicated by adults.

2.2.1.1 Social Play Challenges for Children with ASC

When compared to their TD counterparts, children with ASC have different profiles of social play in various contexts and in range of time periods (Wolfberg, et al., 2012). In free-play conditions, children with ASC may be perceived by their peers as (Wolfberg, et al., 2012):

1. Aloof because some tend to avoid or withdraw from peers.
2. Passive because some merely watch or, at most, imitate peers.
3. Strange because some approach peers and talk to them in an idiosyncratic manner.

Although these behaviours may say otherwise, children with ASC share many of the same desires and capacities for play, friendship, and peer-group acceptance as TD children

[3] Behaviour problems such as throwing tantrums and opposition to and withdrawal from parents and peers.

(Bauminger, et al., 2008) (Bauminger, et al., 2000). Children with ASC are often misunderstood because their initiations of play interests are often ambiguous for peers to recognise and respond to positively (Boucher & Wolfberg, 2003) (Jordan, 2003). As a result, they are more likely to be ignored by tolerant and benevolent peers and taunted or bullied by those more intolerant and malevolent (Sterzing, et al., 2012) (Wolfberg, et al., 1999).

Consequently, children with ASC often quit trying and withdraw from their peers after failed attempts to initiate social interaction (Wolfberg & Schuler, 1993; 2006). For many children with ASC, repeated neglect or rejection by the peer group feeds a cycle of social isolation and play deprivation, which can have a significant effect on adulthood as it affects their development and psychological well-being (Ghaziuddin, et al., 2002) (Mayes, 2011). This observation reiterates the presence of aforementioned reciprocal effect in social interaction between children with ASC and their TD peers.

2.2.1.2 IPG Intervention Practices

Integrated Play Groups (IPG) intervention, also known as guided participation, supports both novice and expert players by allowing them to initiate and incorporate the desired activity into socially coordinated play. Hence, it challenges novice players to practice new and increasingly complex forms of play (Wolfberg, et al., 2012). For children with ASC (novice players), IPGs try to foster each child's development and his/her motivation to play, socialise and form meaningful relationships with their peers. For TD children (expert players), IPGs place the emphasis on acceptance and the need to respond to children with ASC (Wolfberg, et al., 2012). In this way, novice and expert players can mediate their own play activities with minimal adult guidance (Wolfberg, et al., 2012). Depicted below in Figure 2 is a set of overlapping practices for guided participation:

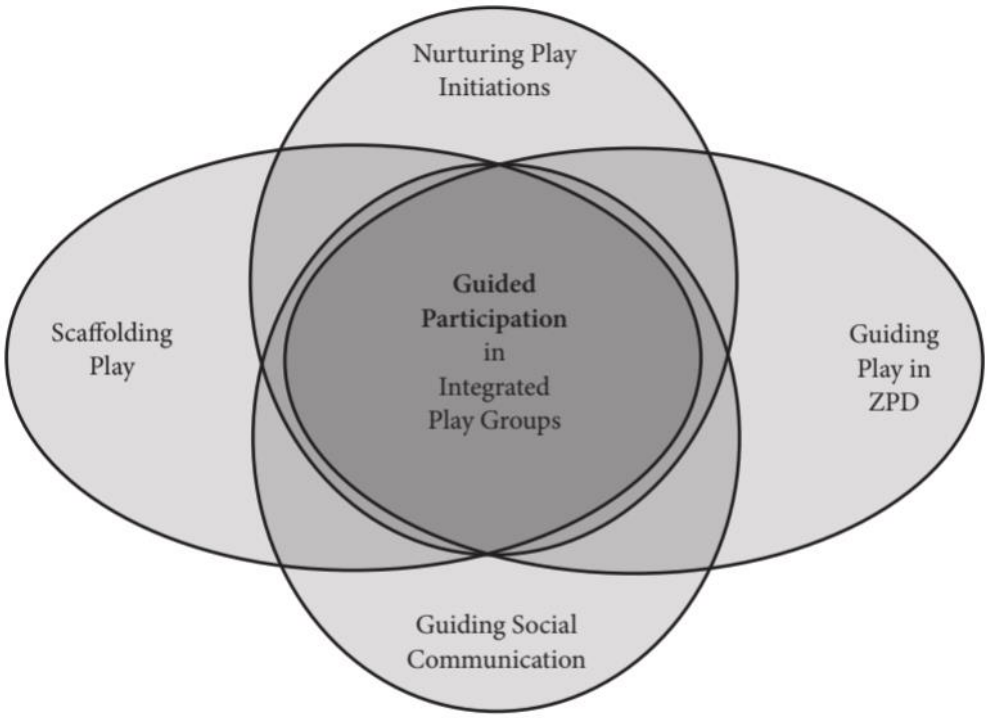

FIGURE 2. CONCEPTUAL MODEL OF GUIDED PARTICIPATION IN IPGS (WOLFBERG, ET AL., 2012)

1. **Nurturing play initiations**
   Play initiations refer to any act or display directed at oneself, one's peers, or materials involved in the play which may be conventional or unconventional i.e. unusual fascinations or obscure forms of communication (Wolfberg,et al., 2012). By recognising, interpreting and responding to each child's play initiations, novice and expert players can become involved in mutually engaging activities, creating a foundation on which novice players can expand their social and symbolic play repertoire (Wolfberg, et al., 2012). For example, other children may interpret the behaviour of a child with ASC who chooses to hide under a blanket as a desire to play hide-and-seek (Wolfberg, et al., 2012).

2. **Scaffolding play**
   Finding the right amount of support without hindering the natural flow of play means systematically adjusting the assistance offered to the child so that he/she can independently play with peers (Wolfberg, et al., 2012). The adult may initially direct the play and model behaviour before the children gain confidence to play together. Then, by posing questions, commenting and offering subtle suggestions using both gestures and visual supports, the adult should act more like an interpreter and coach. By the time the children become fully engaged in reciprocal play, the adult should take a step back to allow them to play on their own (Wolfberg, et al., 2012).

3. **Guiding social communication**
   Social-communication guidance consists of using cue cards and posters to help children learn how to invite and join peers in play and to maintain and expand play interactions (Wolfberg, et al., 2012). The practice supports verbal and nonverbal social communication to elicit attention and to sustain engagement in play. Expert players learn to understand subtle, nonverbal cues of novice players while novice players learn to participate in the play and break down the complex social cues of expert players (Wolfberg, et al., 2012). Hence, both players are able to meet in the middle and communicate with each other better.

4. **Guiding play in the Zone of Proximal Development (ZPD)**
   Zone of Proximal Development is the present capacity of children with ASC in play with peers. By supporting novice players just beyond their ZPDs, they are encouraged to continue develop themselves to gain pace with their peers. For example, while mutually engaged in intrinsically motivating activities and themes, novice players might perform actions and roles that they may not yet fully understand (Wolfberg, et al., 2012). Techniques used by IPGs for this purpose includes orientation, imitation or mirroring, parallel play, joint focus, joint action, role enactment and role playing (Wolfberg, et al., 2012).

Play Scenario	Nurturing Play Initiations	Scaffolding Play	Guiding Social Communications	Guiding Play in ZPD
The session opens with a ritual greeting and a recap of the last session. The teacher asks the children to think of things they would like to play together.	recognize play initiation	intermediate support—verbal and visual cueing		
Kaj heads directly to the play grocery store and begins lining up tins on the shelf, reading aloud each package label. Josh and Ute (expert players) gravitate to the grocery store and stand behind the cash register. Mila and Kesha (novice and expert players) say they would like to play dolls				
The teacher suggests that Mila and Kesha go shopping with their babies while Kaj, Ute and Josh work together in the store. Pointing to the picture cue, the teacher says, "Kaj and Josh, why don't you take turns stocking the grocery shelves and stamping imaginary price labels on each item."	interpret and respond to play initiation	intermediate support—verbal and visual cueing	reinforce cue—what to do—"take turns"	joint action / role enactment
Together the boys line up tins, boxes and play food on the shelves. Using a plastic tube, Josh pretends to stamp labels on some of the items, "Okay, 95 cents for cereal, 75 cents for soup, 25 cents for ice cream."		minimum support—standing by		joint action / role enactment
Pointing to a poster with a corresponding cue, the teacher tells Kaj to watch what Josh is doing.		intermediate support—verbal and visual cueing	reinforces cue—what to do—"watch"	
Kaj watches. Josh next hands him a red block and shows him how to "stamp" the rest of the items. Kaj takes the block and imitates the action by stamping several new items and saying, "Danon yogurt, 25 cents, Rice-a-roni, 25 cents, Corn chips, 25 cents		minimum support—standing by		joint action / role enactment
Meanwhile, Mila and Kesha begin loading a shopping cart with grocery items. Ute others Kaj the role of bag boy while she runs the cash register. Kaj follows Ute and stands beside the cash register. Ute hands Kaj a paper bag and shows him how to hold it open. Kaj waits for further direction.	recognize play initiation	minimum support—standing by		
The teacher steps in and demonstrates each step of the check-out sequence. She suggests that Ute say "take" to Kaj, each time she gives him an item to put in the bag.	interpret and respond to play initiation	maximum support—directing and modeling	reinforce cue—what to do "take"	joint action / role enactment
The children establish a rhythm. Mila and Kesha take turns unloading the shopping cart one item at a time—Ute rings up each item on the cash register and hands the item to Kaj—Kaj puts each item in the grocery bag.		minimum support—standing by		joint action / role enactment
When they finish checking out, Ute tells the shoppers, " Thank you for shopping at Safeway supermarket, have a nice day" The shoppers say, "Thank you, bye-bye."				
The teacher probes, "What should the bag boy say?" Ute tells Kaj to say, " Thank you, bye-bye, have a nice day," which Kaj repeats with a beaming smile.		intermediate support—verbal cueing	introduce cue—what to say—"Thank you …"	role enactment

FIGURE 3. CASE ILLUSTRATION OF GUIDED PARTICIPATION (WOLFBERG, BOTTEMA-BEUTEL, & DEWITT, 2012)

2.2.2 LEAP: TD Peers as Intervention Agents in Classrooms

Peers as teaching confederates/ intervention agents is viewed as a major part of programs designed to increase social behaviour in children with ASC (Tremblay, et al., 1981). For example, *Learning Experiences… An Alternative Program for Pre-schoolers and Parents* (LEAP) is an attempt to incorporate a peer-based model of child treatment into a total preschool program. A group of children with ASC (mean age of 3.5 year) were integrated into the LEAP program together with TD children aged 3-5 years. The TD children were taught systematically to aide their classmates with ASC i.e. asking him/her to play or giving him/her toys to play with (Strain, et al., 1985).

The roles of peers as instructional resources in the LEAP model are as:

(a) Indirect mediators of behaviour change

Group-oriented contingencies as procedures to manage children's behaviour in classroom settings have been shown to be as effective as individually based contingencies (Litow & Pumroy, 1975). Interdependent reinforcement contingencies were observed to be the most efficient based on the resultant level of socially appropriate behaviours expressed by students with ASC. Interdependent reinforcement contingencies refer to making each student's outcome depend upon a level of group performance (Litow & Pumroy, 1975). Interdependent condition is assumed when all members of a group must perform to a minimum standard before any member of the group can achieve some positive consequence (Gamble & Strain, 1979).

(b) Behaviour models

TD children were proposed to model appropriate behaviour for children with ASC (Bricker, 1978) (Guralnick, 1976) (Peck, et al., 1978). However, children with severe difficulties in observational learning skills are less likely to benefit from this method (Strain, et al., 1985).

(c) Direct agents of training

For young TD peers to be effective intervention agents for children with ASC, care have to be taken in the training of peer trainers. Similar to IPG intervention process, the TD peers were taught to expect rejection and despite that, try hard to get other children to play with them (Strain, et al., 1985).

When compared to the study's baseline "Stars" programme[4], it was shown that LEAP children's average reduction in 'deviant behaviour' was more than twice the amount for "Stars". This shows that developmentally-integrated programming improves children with ASC's social behaviour (Strain, et al., 1985).

[4] Developmentally-segregated settings

2.2.3 Adaptive Teacher Intervention

In 1987, 17 experienced teachers who teach children with ASC (mid to far end of the spectrum) were taught to train TD peers to increase social interaction of their most severely withdrawn children in schools. Their teaching tactics were then observed. From the analysis, it was shown that simply providing social integration opportunities (i.e. placing children in the same room) and informing TD peers about ASC conditions and methods of interacting with student with ASC will not ensure social integration (Shores R. E., 1987). It was concluded that teachers must provide direct instruction during the interaction to increase desired social interaction among TD children and children with ASC.

On the contrary, a more recent study (consisting of 137 children with ASC) has shown that the type of social skills intervention teachers take should differ according to quality teacher-child relationships (Kasari, et al., 2016). Children with low teacher child closeness or high conflict has socially benefitted more from didactic intervention group (child receives didactic, direct instruction on social skills) composing only of children with ASC (Kasari, et al., 2016). On the other hand, children with higher teacher-child closeness benefited more if they were in shared interests based intervention group (child learns from shared activities with other children and naturalistic teaching) composing of 2-3 chosen [5] TD peers to one child with ASC (Kasari, et al., 2016). Hence, it is important to note that individualising treatment approach based on child characteristics improves his/her social skills learning outcome.

2.2.4 Other Studies

A few more pointers were found on peer mediated intervention which will be helpful in forming game design decisions later on:

1. It was suggested that social interactions by students with ASC were more likely to occur in an integrated (with other TD students) free play setting than in segregated setting (Hecimovic, et al., 1986). This may be due to TD peers providing more opportunities for withdrawn children to engage in newly acquired social behaviour than children with difficulties because TD children initiate social interactions and respond to others' initiations more consistently and more often (Strain & Shores, 1983). Hence, integrated setting provides more opportunities for practice and a more reinforcing environment for social skills training (Shores, 1987).

2. Spontaneous interactions among children was found to decrease when an adult is nearby during free play (Shores, et al., 1976). Thus, certain setting factors can influence interaction.

2.3 Augmented Reality[6]

Augmented Reality is a general term for technologies that superimpose virtual contents onto the real world. As seen from the diagram below in Figure 4, 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

[5] TD peers were selected based on having good social skills (positive role models). (Kasari, et al., 2016)

[6] From my 2017 MInf 1 project, Peter's Adventures: A tablet app to elicit pretend play for Children with ASC

video fed to the screen (Vallino, 1998). The end result is an augmented live video played on the screen.

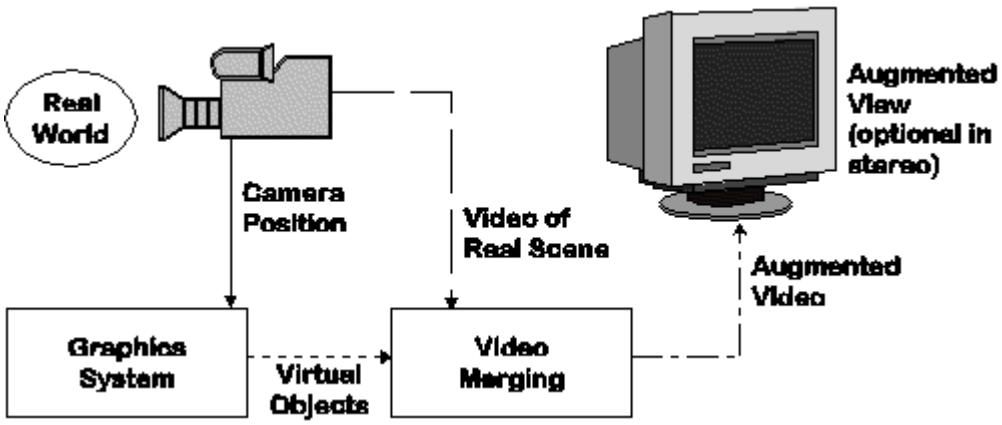

FIGURE 4. AN OVERVIEW OF AN AR SYSTEM (VALLINO, 1998)

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[7] or sensor-based tracking[8]. 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.

2.3.1 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):

- **Effectiveness**
  The accuracy and completeness with which users attain specific goals.
- **Efficiency**

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

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

The efficiency of attaining specific goals given available resources.

- **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 in the related work section (2.3.5).

2.4 Pretend Play[9]

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.

2.4.1 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).

[9] From my 2017 MInf 1 project, Peter's Adventures: A tablet app to elicit pretend play for Children with ASC.

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.

2.4.2 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[10] (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 and divergent thinking, language literacy, impulse control, perspective taking and socialisation.

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

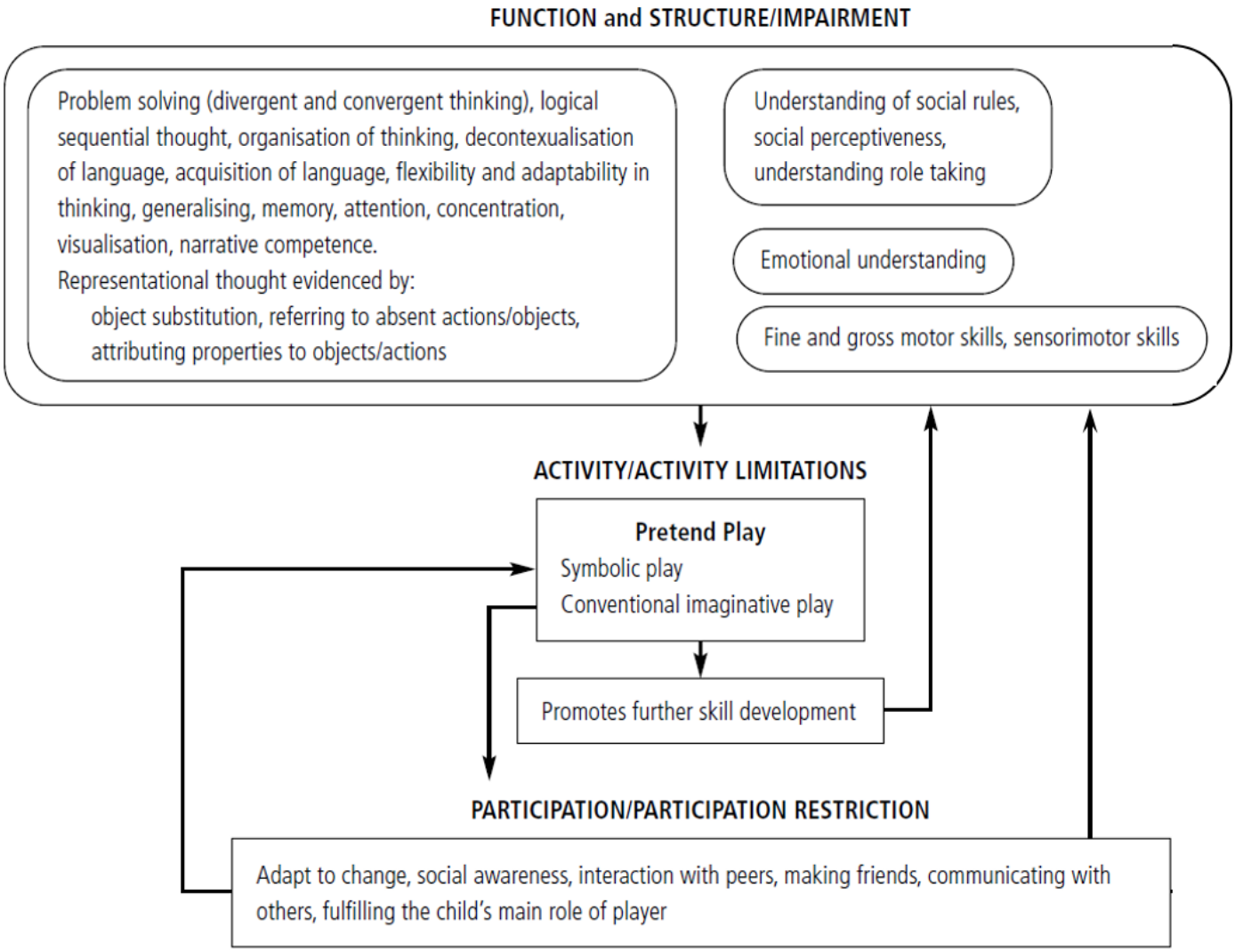

FIGURE 5. A MODEL OF PRETEND PLAY BASED ON WORLD HEALTH ORGANISATION'S (WHO) CLASSIFICATION SYSTEM (STAGNITTI & UNSWORTH, 2000)

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).

2.4.4 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).

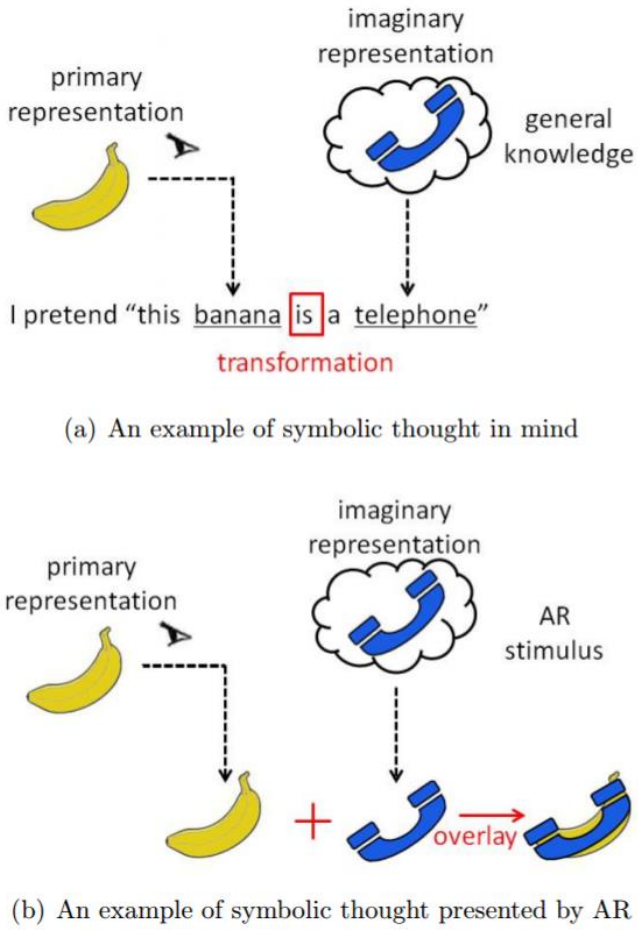

FIGURE 6. EXAMPLES OF SYMBOLIC THOUGHTS BEING REPRESENTED (BAI, 2014)

As shown in Figure 6(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 6(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 have 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).

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).

2.5 Related Work and Further Studies

2.5.1 Main Research

Recent research has explored 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).

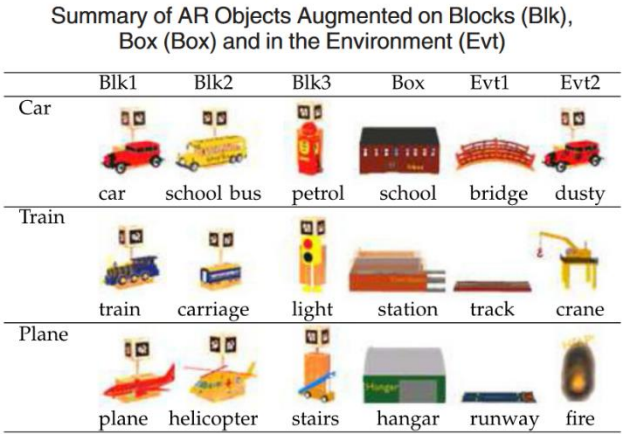

FIGURE 7. SYSTEM SETUP WITH USER AND SUMMARY OF AR OBJECTS AGUMENTED (BAI, BLACKWELL, & COULOURIS, 2015)

2.5.2 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.

(a) Enact puppet (b) Transform emotion (c) Open-ended scenery objects (d) Dramatic storyline

FIGURE 8. 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"[11] to 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, the play process can be more fun by integrating the AR technology into a game environment.

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

2.5.3 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 9. 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.

2.5.4 Pico's Adventure

Pico's Adventure is a Kinect-based game aimed at promoting social initiation in young children with ASC. By choosing to focus towards a cooperative model (instead of player 1 vs player 2, or team competition) for their game design patterns, synergies between different user abilities, shared goals and complementarities of players actions were taken into account (Malinverni, et al., 2017). Cooperative design pattern will be further elaborated in the Game Design section (Chapter 4).

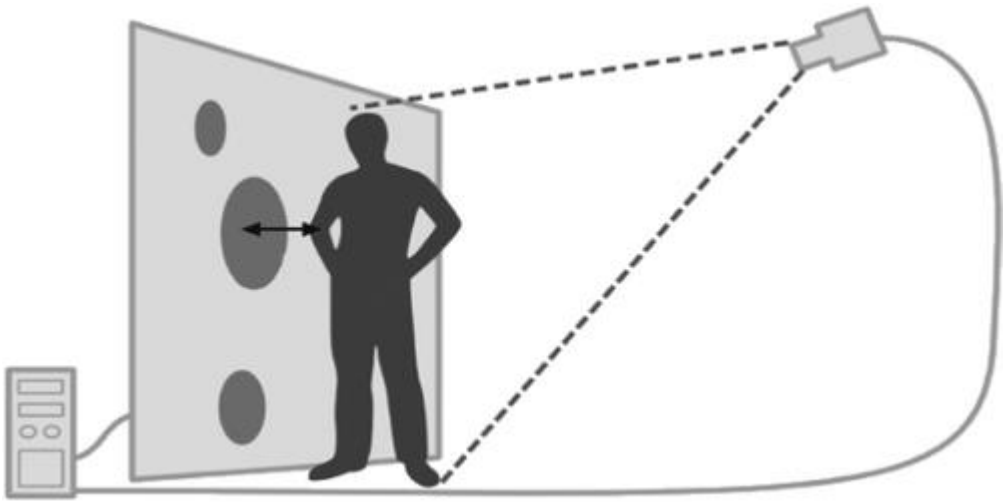

FIGURE 10. KINECT-BASED GAME SETUP (CROWELL, MORA-GUIARD, & PARES, 2017)

During the game design stage, psychologists were consulted to define a set of behavioural skills that are usually addressed within traditional treatments for fostering social initiation (Malinverni, et al., 2017). The session-specific behaviour sub goals mentioned are (Malinverni, et al., 2017):

- *Use of instrumental gestures and conventional gestures*
  i.e. child gestures to obtain a target object
- *Stimuli discrimination*
  i.e. child has to discriminate between target object and non-target objects
- *Turn-taking*
  i.e. two children having to coordinate in order to achieve a game goal
- *Joint attention*
  i.e. child has to call the attention of another person toward target objects through point gesture
- *Vocalization*
  i.e. child has to use vocalisations to ward off an antagonist of the game
- Cooperation
  i.e. child has to cooperate with another person to coordinate their pointing gestures towards target objects

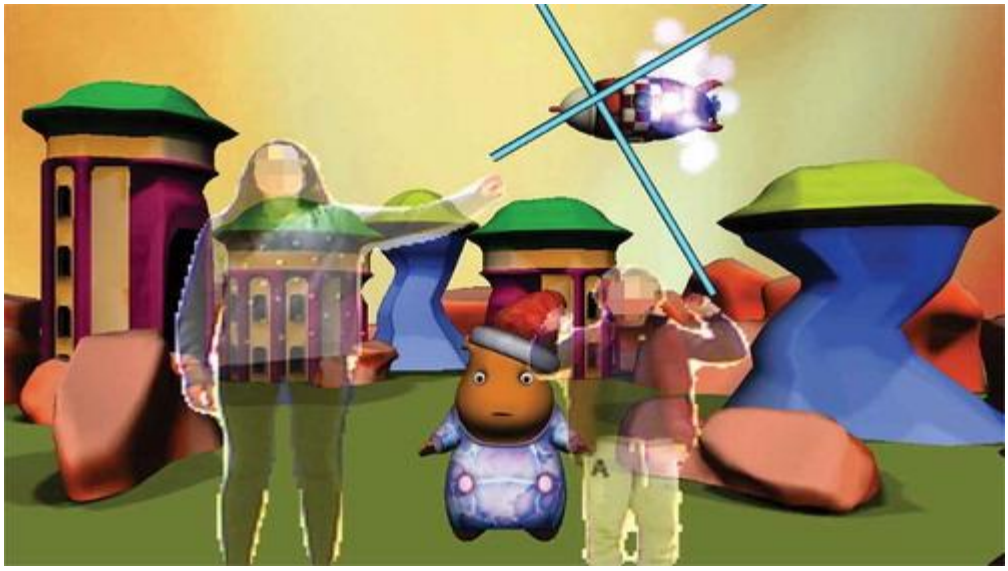

FIGURE 11. PICO'S ADVENTURE GAMEPLAY (MALINVERNI, ET AL., 2017)

From game evaluation with 10 children with ASC, it was found that the children enjoyed the game and several behaviours related to social initiation were observed (Malinverni, et al., 2017). Thus, it would also be useful to consider the following design guidelines concluded by the project:

1. To encourage behaviours related with social requests, it is advisable to have a cooperative game mechanics where different resources are distributed between players to achieve a common goal (Malinverni, et al., 2017).
2. Game mechanics with physical contact should be avoided since they may inhibit social communication by encouraging an instrumental use of the other player (Malinverni, et al., 2017).
3. Surprising and unexpected elements can facilitate social initiation (Malinverni, et al., 2017).
4. "Peephole" design strategy encourages exploration and avoid repetitive behaviours (Malinverni, et al., 2017). By restricting the view (of the user) to reveal only a small section of the scenario, the strategy aims to pique curiosity and promote exploration through discovery of the unknown (Crowell, Mora-Guiard, & Pares, 2017).

These design guidelines and behaviour goals during gameplay, if relevant, will be applied later on in the Game Design section (Chapter 4).

2.5.5 Collaborative Puzzle Game

Although Pico's Adventure is a collaborative game, it did not address design strategies for multiplayer screen-based interfaces. Research has shown that with appropriate interface support, children with ASC possess latent abilities to coordinate social interaction (Holt & Yuill, 2014).

Children with ASC tend to lack awareness of the other person as a partner during interactions (other awareness), contributing to marked deficits in reciprocal social interaction, such as a lack of sharing enjoyment and interests with others (American Psychiatric Association, 2013) (Holt & Yuill, 2014). Through the use of Separate Control of Shared Space (SCoSS) interface,

active and attentional other-awareness[12] was found to have increased in children with low functioning autism during a picture sorting game with a TD child (Holt & Yuill, 2014). Interestingly, in both SCoSS and non-SCoSS set ups, the research has also shown that active other awareness is increased when the child with ASC has a peer partner rather than an adult (Holt & Yuill, 2014).

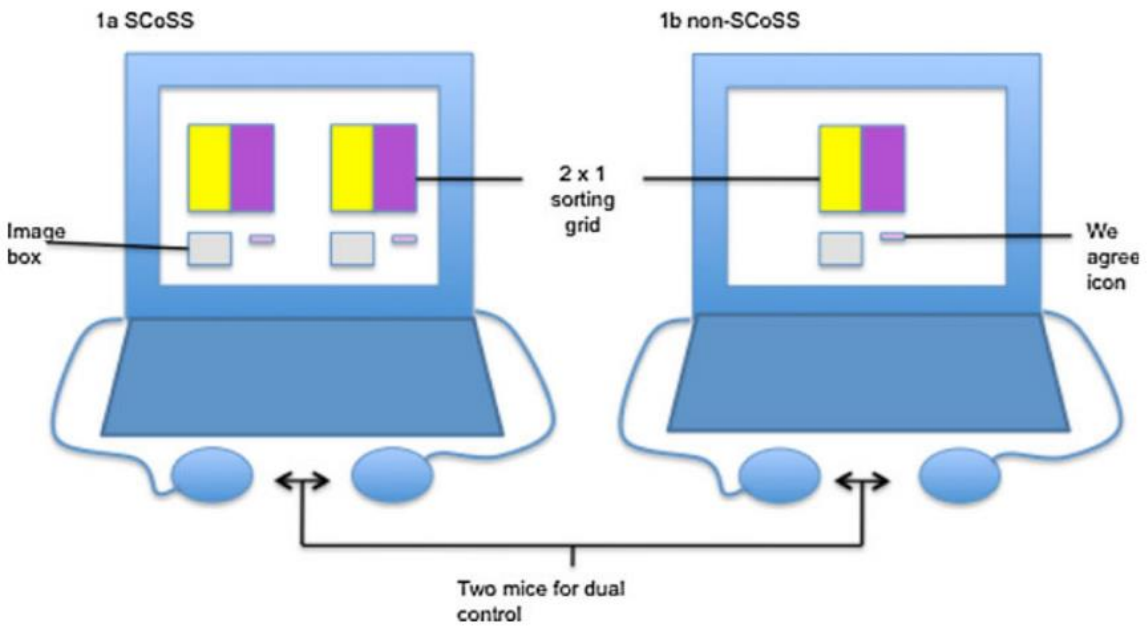

FIGURE 12. SCOSS AND NON-SCOSS SCREEN INTERFACES (HOLT & YUILL, 2014)

The SCoSS interface consisted of four special features to support collaboration and shared understanding:

1. Users have the same task to solve, with representations of both their own task states and their partner's on the same screen as shown in Figure 12. SCoSS and non-SCOSS screen interfaces (Holt & Yuill, 2014).
2. Each user has a mouse that controls their own task space but cannot control any of their partner's task elements (Holt & Yuill, 2014).
3. Explicit achievement of agreement representation whereby when both users place identical task pieces in corresponding task spaces, the agreed items are highlighted green (Holt & Yuill, 2014).
4. Having points in the task where both users have to come to an explicit joint agreement about where the task pieces are placed (i.e. by clicking the 'We agree' icon shown in Figure 12. SCoSS and non-SCOSS screen interfaces) (Holt & Yuill, 2014).

There is a significant emphasis on separated workspaces and progress in the SCoSS interface as compared to the non-SCoSS interface. It was evidenced that because children with ASC have both sensory processing and motor impairments, their ability to take part in computer

[12] Active other awareness: The child's action is related to and intentionally contingent with on the action of his/her partner (Holt & Yuill, 2014).

Attentional other awareness: The child's behaviour is related to but not contingent to partner's actions (i.e. child watching partner performing an aspect of the collaborative task before continuing with his/her own related but non-contingent action) (Holt & Yuill, 2014).

activity is affected (Dawson & Watling, 2000). The side-by-side arrangement of the workspace in the SCoSS interface alleviates sensory processing workload by making it more distinguishable where one's workings is (in relation to partner's workings) (Holt & Yuill, 2014). Moreover, having a smaller screen space reduces required motor control to complete a task (i.e. moving mouse within screen space), hence, children with ASC may find it easier to navigate within their section of the screen (Holt & Yuill, 2014).

FIGURE 13. EXAMPLE OF ATTENTIONAL OTHER AWARENESS: LFA CHILD (RIGHT) HAS PLACED HIS 3RD POSTMAN PAT PICTURE (LEFT-SIDE GAME) THEN REMOVED HIS HAND FROM HIS MOUSE AND TURNED TO WATCH AND WAIT FOR HIS PARTNER TO CATCH UP (TEACHER IN CENTRE). (HOLT & YUILL, 2014)

By increasing other awareness in children with ASC, joint activity is supported and encouraged (i.e. turn taking whereby one child waits for the other to perform a prerequisite action before following up, which without waiting for the other to act would not result in a required outcome (Holt & Yuill, 2014)). Thus, design guidelines from the research will also be utilised in the Game Design section (Chapter 4).

CHAPTER 3

PRE-DESIGN STAGE

This chapter presents the initial stages of the design process which includes a methodology section which informs the research question and structure, and a design workshop section which discuss activities carried out to inform the game design. Observations are valuable to gaining insight into how children interact with each other and with their tools in natural setting, allowing researchers to better understand the user's process, context and goals (Preece, et al., 2011). Observing how users interact with existing technologies can also contribute to informing design of new technologies (Druin, 2002).

3.1 METHODOLOGY

3.1.1 FORMING RESEARCH QUESTION

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

1. 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 (Chapter 2.4.1).

2. By nurturing play initiations, scaffolding play and providing social-communication guidance, children with ASC can learn to initiate and incorporate activities (social or symbolic play) into coordinated play with other children (Chapter 2.2.1).

3. Compared to children with ASC, TD children are more likely to act as a behaviour model for children with ASC or at the very least, provide them with opportunities to engage in new social behaviour. Moreover, having interdependent reinforcement contingencies in a group setting helps increase desired behaviour of children with ASC (Chapter 2.2.2).

4. To increase desired social interaction between TD children and children with ASC, a balance of didactic, direct instructions and shared activities are needed to accommodate for children with ASC's different needs (Chapter 2.2.3).

5. 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 (Chapter 2.4.2).

6. 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 (Chapter 2.5.1).

7. When playing on a SCoSS-like screen interface, active other awareness is likely to increase in children with ASC if they play with a peer on as compared to with an adult (Chapter 2.5.5). Other awareness is important in joint collaborative activities with others.

These findings suggest that a peer support AR game app can be used for young 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 can a game be designed to encourage pretend play for children with ASC?

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.

3.1.2 Game Framework And Research Questions

Charades is chosen as the main gameplay structure on which the game design will be built on. This is because the game encourages a lot of communication (series of questioning and answering) between players and is centred around pretence. Charades is a multiplayer word guessing game during which a player would draw a slip of paper from a box and silently read the word written on it. Then, he/she would try to convey this word to his/her peers through miming without using any spoken words. To avoid confusion, the role of this player would be called the **mime** while the role of the player trying to guess the mime's word is called the **guesser** throughout this paper.

By altering the 'word' choice categories in the game, charades can be suitable for children aged 4 and older[13]. For example, children friendly categories may be: animal kingdom (word may be 'dog', 'crocodiles' etc.), who am I? ('princess', 'fire fighter' etc.), or things with wheels ('train' etc.). At 4 year old, TD children usually are able to (University of Pittsburgh Office of Child Development, accessed Nov 2017):

- Respond to questions such as "Whose?" and "Why?"
- Use complex sentence
- Talk about things, people and activities not currently happening
- Be cooperative with peers, especially in group activities
- Pretend they are other people and play dress up
  Pretend play ability starts at age of 3 year old (Chapter 2.4).
- Read and write name

[13] Examples of published charade games with age rating of 4+ :

A. Paul Lamond Games, Charades For Kids, http://paul-lamond.com/children-s-games/59-charade-for-kids.html, accessed October 2017.

B. App Store, Heads Up! Kids by Warner Bros. Entertainment, https://itunes.apple.com/gb/app/heads-up-kids/id937976391?mt=8, accessed October 2017.

C. App Store, Charades! Kids by FatChicken Studios, https://itunes.apple.com/us/app/charades-kids/id663084496?mt=8 , accessed October 2017.

As TD peers used to socially assist children with ASC are of age 3 and above (i.e. in IPG or LEAP model) (section 2.2) the game app will be aimed at TD children aged 4 and above to compensate for comprehension of charades gameplay structure as well.

The game's target users are 4-6 years old children with high-functioning autism (HFA). HFA is used to refer to people with ASC with higher cognitive development than other people on the spectrum and hence, have more chance of having an autonomous life if adequately assisted through their childhood and adolescence (Malinverni, et al., 2017). From specialists in Pico's Adventures project, the inclusion criteria for having HFA are (Malinverni, et al., 2017):

1. A minimum non-verbal IQ level of 70 so that the child would most likely be able to understand the environment and hence, the game mechanics.
2. An autism diagnosis with the ADIR diagnostic tool.
3. A diagnosis of ADOS Module 3 minimum level 4 so that the child have fluent verbal capacity to play the game.

In addition, research has shown that early intervention in higher functioning children with ASC has better progress reports (Ben-Tzchak & Zachor, 2007) (Smith, 2006).

3.1.2.1 Revised Charades Game Framework

To accommodate for the purpose of eliciting pretend play for children with ASC, the common charades game structure will be altered to suit the levels of the target users. For example, instead of making the mime act out to cue his/her word, several types of verbal and non-verbal cues can be integrated to allow for involvement of players who cannot pretend play yet. These cues may be textual hints (like hangman) or deduction hints (letting the guesser ask yes-or-no questions to guess the word). Possible game variations will be further explored in Chapter 3 and Chapter 4.

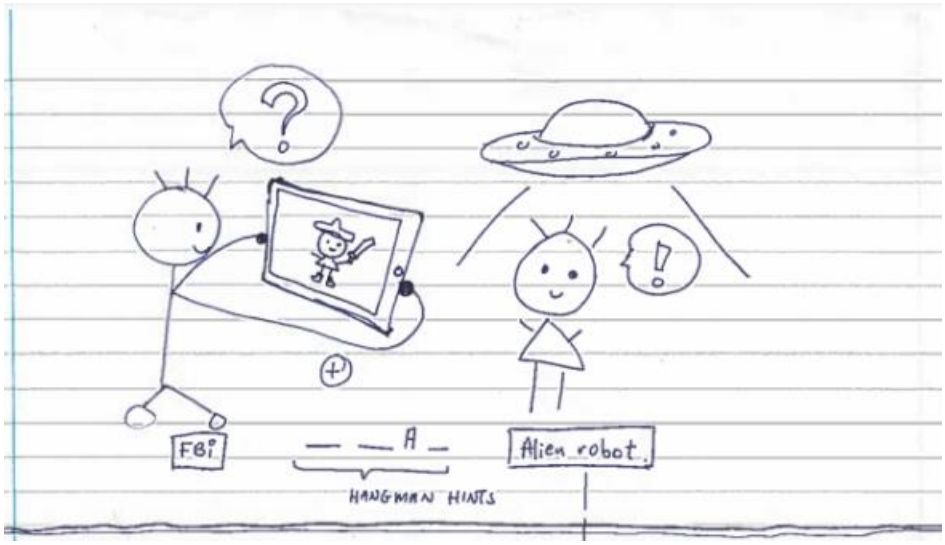

FIGURE 14. SKETCH OF PLAYERS' INTERACTION USING AR WITHIN GAME STORY

AR is planned to be integrated into the game as visual support for each word. As shown in Figure 14. Sketch of players' interaction using ar within game story, a hat and sword has been augmented on to the girl in the tablet screen held by a boy, making her look like a pirate. Hence, as the AR will be transforming the player onscreen into a specific entity, the categories of charades words would be limited to animal kingdom and 'who am I?' (Personas like clown or ninja) categories. This decision also keeps the game simple as the words within the

categories require little background knowledge in the subject (in comparison to other children charades word categories like cartoon shows or Disney characters). More details on how the altered charades game will flow with AR and the handling of tablet between players will be discussed in Chapter 4.

Also in Figure 14. Sketch of players' interaction using ar within game story, the tags “FBI” and “Alien robot” represent the role each player will be playing within the game’s overarching story. The purpose of a game narrative is to engage and involve both players within the game. Hence, the initial story design was to have one player play a character (i.e. an alien robot) who goes through various transformations in order to evade the other player playing as a character (i.e. a secret agent/ detective) who is chasing him/her. The connection between the game story and the charades gameplay has yet to be confirmed. This aspect of the game will be revised and discussed in Chapter 3 and Chapter 4.

3.1.2.2 Game Summary and Research Questions

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

- the actions the players will have to take in order to describe an imaginary entity (i.e. meowing for a cat)
- transformation of players into different entities using masks (i.e. whiskers) augmented onto them

Verbal interaction and pretence will be the main actions required by the players. These design framework decisions, thus, allow children with ASC to learn from or engage in a simple level of pretend play with other TD children. This ensures that the child with ASC will find it easier to understand the concept of having symbolic thoughts as compared to having no guiding structure at all.

Moreover, increasing the players’ intrinsic motivation will be the main focus of the game design so that they associate the social and symbolic play with positive feelings. Thus, encouraging the child with ASC to initiate pretend play actions independently with his/her peers.

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 and TD children?
2. **Satisfaction:** Will the target groups 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?

3.1.3 Participatory Design[14]

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)

[14] From my 2017 MInf 1 project, Peter’s Adventures: A tablet app to elicit pretend play for Children with ASC

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 design informants and work 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. Querying 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 (Chapter 4) to clarify design objectives.

3.1.4 Research Structure

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

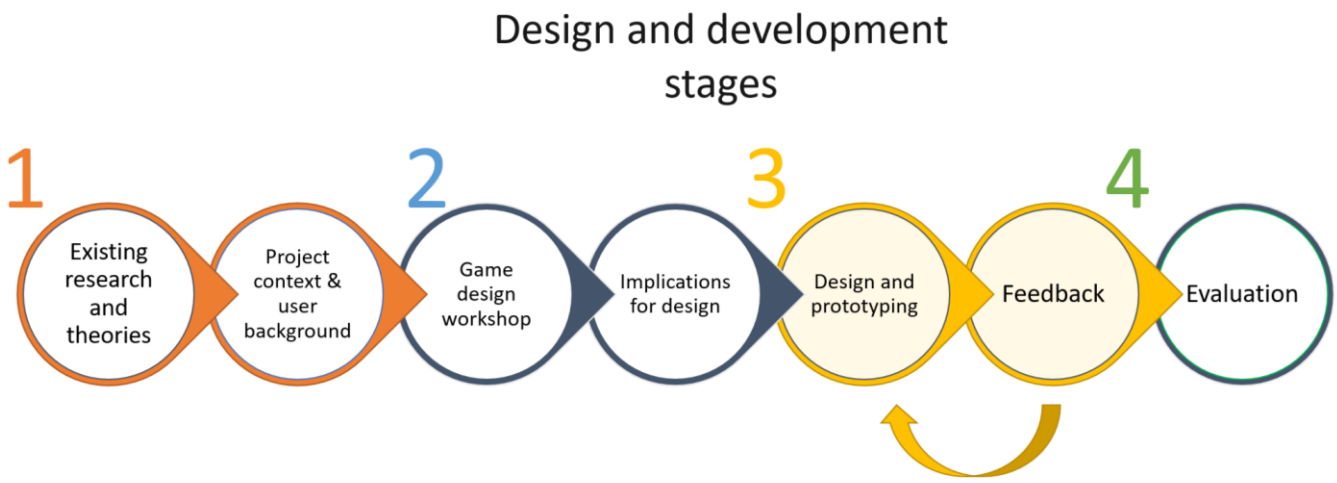

FIGURE 15. DIAGRAM OF THE PROJECT'S DEVELOPMENT PLAN

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 suggestions on required social game rules and dynamics for young children by observing them play a social game.
   c. Get game design and augmentation entities 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 take part in a social game and design the possible game augmentations (Chapter 3). 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 (Chapter 4) 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 (Chapter 4).

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 during game testing workshops (Chapter 5). 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 5).

3.2 Children Design Workshop

Two main sets of observations were carried out in design workshop sessions to gain understanding of the techniques used to create a fun social game for young children. The observations were also important in gaining insight into how children interact and react to these techniques. The results of the pre-design activities will be used to produce user specific requirements and help inform future design of the game.

3.2.1 Aims

The aim of this game design workshop was to see how children (aged 6-13 year-old) interact with an augmented reality app on a tablet and with each other during a social game called charades so that informed design decisions can be made later on. Charades was chosen because the traditional game requires both pretence and a lot of communication between two players. The ease of use of the tablet application and the difficulties children may have with the charades gameplay was also observed. Lastly, the game entities (charades words) which will take form as augmented mask filters (shown later) and game story were designed by the children.

3.2.2 Observation Design

3.2.2.1 Participants

There was a total of 3 TD boys and 12 TD girls (6 to 13 year-old) in 5 group sessions. 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	Female	9	Yes
S2	Female	6	
S3	Female	6	
2nd Group			
S4	Female	12	
S5	Male	13	

Workshop 2			
Child	Sex	Age	Siblings
S6	Male	9	
S7	Male	8	
S8	Female	8	
S9	Female	6	

Workshop 3			
Child	Sex	Age	Siblings
1st Group			
S10	Female	9	
S11	Female	9	
S12	Female	9	
2nd Group			
S13	Female	8	
S14	Female	9	
S15	Female	8	

3.2.2.2 Setting

Two workshops (Workshop 1 and Workshop 2) were carried out in a comfortable environment while one was carried out in a games hall environment. No parents were present during 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.

3.2.2.3 Materials

During the workshop, the main materials used were: a Samsung Galaxy tablet, a printed marker on a string (to be worn like a necklace and is adjustable by pulling the marker along the string) as shown in the left image of Figure 16 and a sheet of worksheet for each child (Figure 17). From previous work[15], it was noted that the camera could not focus properly on small images with low contrast due to the tablet's camera resolution and current AR technology. Thus, a large black and white logo was used for easier detection and tracking.

FIGURE 16. MAIN MATERIALS USED FOR THE WORKSHOP (LEFT) AND TABLET SCREENSHOT OF RUNING AR APP (RIGHT)

[15] From my 2017 MInf 1 project, Peter's Adventures: A tablet app to elicit pretend play for Children with ASC

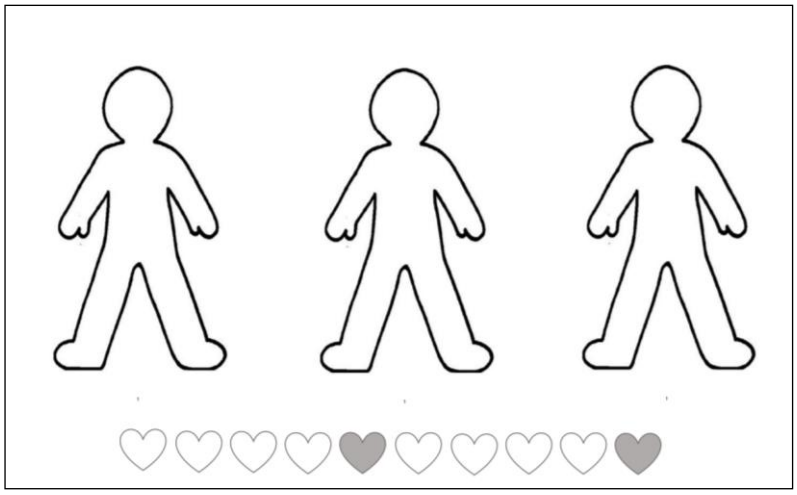

FIGURE 17. WORKSHEET CONTAINING FIGURES FOR CHARADES AR DESIGN

The AR application used was built using Vuforia[16] augmentation package on a Unity 3D game engine[17]. 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 the left image of Figure 16. For the workshop, the AR system is of a hand-held design as it is more mobile and enable better viewing of 3D augmentation objects. Also, the children will not have to divide their attention as much as a screen based display.

Prior to the workshop session, 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).

3.2.2.4 Procedure

After the parents have 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 assured 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 audio recorded while the researcher is engaged with the children so that their interactions 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.

I. The group of children were asked if they have heard of Snapchat filters and the game of charades or 'Who am I?'. The combination of both elements in the intended game design was explained and then the AR application on the tablet was introduced to them while one of them wear the marker in Figure 16. Main Materials used for the workshop (Left)

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

[17] https://unity3d.com

and tablet Screenshot of runing AR app (right)Figure 16. The tablet and the marker were then swapped around so all could see the augmentation.

The children were then told they will each be playing three rounds of charades with emphasis on different hints to be given per round. The worksheet (Figure 17) was given to each child and they were asked to silently come up with a word (an entity) which can be an animal, a type of person or mythical creature. As shown in Figure 18, each outline represents an entity (a charades word, i.e. 'cat') each child will have to come up with per round.

Then, the children were asked to draw 1 to 3 objects on an outline as visual hint so that their peers can guess their entity. If his/her entity cannot be guessed straightaway, the child is allowed to act out the entity, play a mini hangman game (textual cue) with his/her group, answer a yes-or-no question from his/her groupmates or draw more objects onto his/her outline. Each child's entity has to be guessed correctly or be given up on by the group before the next child can have his/her turn.

From Figure 18, Round A emphasised on acting out as a hint, Round B emphasised on textual cues (hangman) as hint while Round C emphasised on getting asked yes-or-no questions as hints. The ten hearts below the figures represent the 'lives' for each yes-or-no question. Hence, for a round, the player can only be asked ten yes-or-no questions in total.

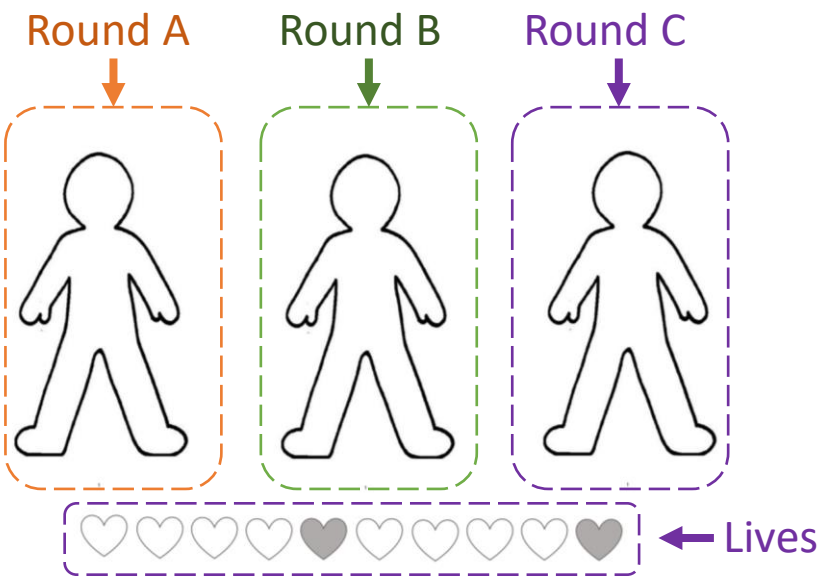

FIGURE 18. A SHEET WITH THREE OUTLINES AND TEN HEARTS REPRESENTING LIVES WERE USED FOR THE CHARADES GAME.

Due to different complexities of each type of hint in relation to the entity a child might come up with, the types of hints rule was flexible and hence, if need be, different types of hints can be used in any round (i.e. for cases where none of the children can guess the entity after a specific type of hint was given).

II. If there is enough time (depends on the length of charades games session), the children will be asked to design the main game characters with coloured pen and paper. They were told to design a story with a character which can transform into any entities and

a character who chases after the transforming character. Examples of well-known transformative characters, Figure 19, were shown to the children for them to better comprehend the character requirement.

FIGURE 19. EXAMPLES OF TRANSFORMATIVE CHARACTERS INFORMATION SHEET

FIGURE 20. DESIGN WORKSHOP BEING HELD

3.2.3 Observation

3.2.3.1 AR Handling

The children across all the three workshops had no difficulty handling the tablet so that the markers can be detected. This may be because the marker is large enough for good detection and tracking even when the child moved around a lot. However, it was noted that a necklace design results in inconsistent angling of the augmentation as the marker gets tilted and worn at different heights. Also, most children found it more convenient to hold the tablet in a

portrait orientation. Most of the children were enthusiastic and inquisitive with the technology. Some wanted to take photos of their peers in the Viking helmet and beard.

3.2.3.2 Charades Game Structure and Design

Overall, the children seemed to get most excited by coming up with an entity that their peers cannot guess and funny identities created by their peers or themselves. After having drawn a few objects, some children proceeded to complete the whole drawing of their chosen entity. This is usually due to them being bored by having to wait around for others to finish their tasks. Some of the entities created by the children are:

TABLE B. ENTITIES CREATED BY THE CHILDREN DURING THE GAME OF CHARADES

Animals	Mythical creatures	Type of people	Miscellaneous
dog	alien	ninja	cloud
cat	unicorn	Japanese man	"Micky mouse pooping out knives and blood"
fox	dragon	Santa	"hippy with rainbow puke and dangly nipple piercings"
elephant	mermaid	pilot	"guy with underpants"
butterfly		Egyptian	"Illuminati girl"
bear		boy scout	window
jellyfish		Hawaiian dancer	hypocrite
		Oompa loompa	strawberry
		baker	Trump
		clown	
		nerd	
		magician	
		Willy Wonka	

Although the Miscellaneous category will not be used to design the game's AR filters, it provided insight on how children socialise. It was noted that even though the children were strangers at first (Workshop 2), they were able to bond and feel comfortable quickly with each other after sharing a series of laughter together about Micky Mouse defecating and a rainbow puking hippy.

Observational notes from different types of charades hints during gameplay are:

- *Action hint*
  Few children attempted to act out their entities even when prompted. This might be due to the specificity or difficulty (challenging to act out) of their chosen entity i.e.

'Willy Wonka', 'jellyfish' as shown in Figure 21. Also, due to the presence of an adult during the session, some children might be shy to act out in front of their peers.

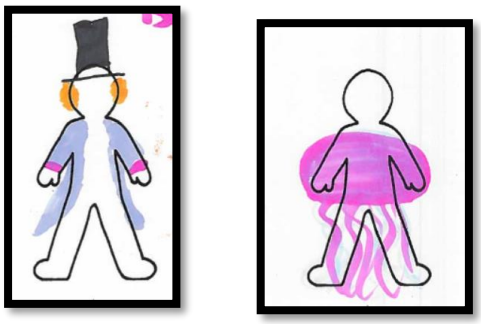

FIGURE 21. CHILDREN'S DRAWING ON OUTLINE EXAMPLE A

- *Hangman (textual hint)*
  Like action hint, few children attempted hangman unless the word is simple i.e. 'cat'. Some children had difficulty with hangman because they could not spell their entity's name i.e. 'scout' while a few misspelled their entities i.e. 'foxy' (Figure 22). Also, when the hangman game was ongoing, it was observed that more children became disinterested/restless.

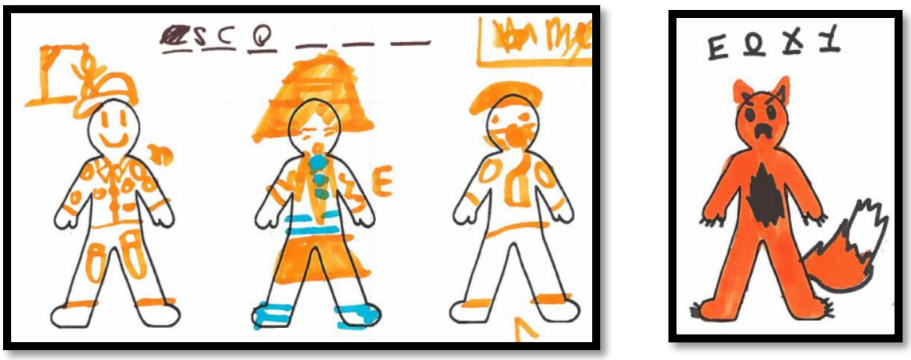

FIGURE 22 CHILDREN'S DRAWING ON OUTLINE EXAMPLE B

- *Answering Yes-or-No questions (verbal hint)*
  It was clear that after about four yes-or-no questions, some children became disinterested in guessing what the entity is. Besides the factor of the entity being too challenging, this is sometimes because they cannot come up with more questions to ask or they were asking very specific questions which did not narrow down the possibilities of entities (no strategic questioning). By the time all the hearts are crossed out (Figure 23), most of the round ended up in the group giving up the round as they still could not guess the entity correctly. Hence, having more yes-or-no questions do not help.

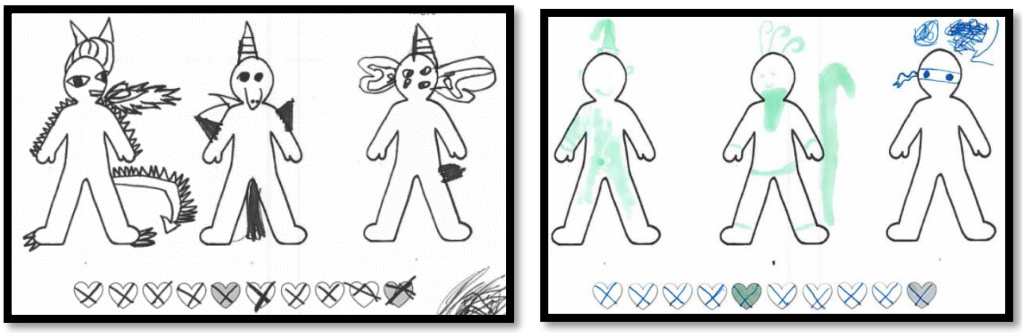

FIGURE 23. CHILDREN'S DRAWING ON OUTLINE EXAMPLE C

- *Visual hint*
  Visual cue is the most popular and easiest (by number of wrong guesses before the right one) hint in the game.

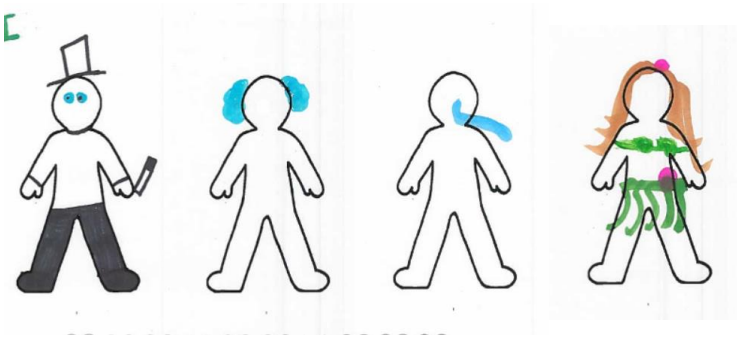

FIGURE 24. CHILDREN'S DRAWING ON OUTLINE EXAMPLE D

3.2.3.3 Game Story Design

It was observed that some children had difficulty grasping the concept of a transforming character and hence, could not come up with suggestions for them. From those who tried, characters such as a Demi-god, a clown, a super hero and a caterpillar were suggested. Most children were not able to come up with a coherent story for the game as the character requirements might have been too complex for them.

3.3 Discussion

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

1. <u>Difficulties in charades</u>
   When selecting entities (charades word), it is crucial that the entity is well-known and is not too specific to a movie/cartoon show (i.e. Charlie and the Chocolate Factory). This to alleviate unfairness in the game wherein the guessers have not even heard of the entity they are guessing. Overall, visual hint (which is going to be presented through augmentation in the game) is the easiest hint for the guessers. Hence, it may be altered to make it more difficult by limiting the amount of objects augmented on the player (i.e. ears without whiskers for a 'cat'). Also, obvious visual cues can be used as part of the round's entity reveal for the mime (at the start of round) or solution reveal for the guesser (at the end of round).

   Hangman hints do not seem to be appropriate for charades as it introduces literacy challenge for younger players. Also, it slows down the pace of the game by making the

players guess letter by letter. As a result, some children became more disengaged during the workshop.

Yes-or-no question hints, however, were helpful for some players (i.e. “Am I an animal?”, “Do I have legs?”) although it should be limited to four or less tries in order to avoid disengagement with peers. Also, even though very few children acted out their entities, some conditioning may help reduce their fear of acting in front of their peers. This will be discussed in the next point below.

2. Effect of adult supervision
   It is crucial to support acting out within the game as it is a form of pretend play (i.e. a child pretending to be a magician by waving an invisible wand while holding a hat). As the children were directly asked to ‘act out’ by the conductor of the workshop, they might have felt shy. Research has shown that spontaneous interactions among children was found to decrease when an adult is nearby during free play (Shores, Hester, & Strain, 1976) (Chapter 2.2.4). Moreover, child pairs who played alone without adult supervision were found to verbalise more and engage in significantly more cooperative play (Besevegis & Lore, 1983). Thus, the observation may have been inaccurate of how children would play in an unsupervised environment.

   Game design tips for collaborative games (Chapter 2.5) will be used to help with the initial social interaction between children and hence, comfortability with acting out in front of their peers. Also, it is important to keep adult intervention to the minimum during the game evaluation phase (Chapter 5) to get a more accurate representation of how the children would interact during gameplay.

3. AR design notes
   From observation, the children preferred to hold up a tablet in portrait orientation while using the AR app. This may be because holding up the tablet (25.4cm x 15.5cm, 525g) with a closer grip is easier for them. Also, the augmentation on a face fits better on-screen when viewed in portrait mode.

   Some alterations have to be made to the marker necklace so that augmentation’s position in relation to the wearer will be consistent even when the player moves. The marker should also be independent of the player’s size as having the marker’s position adjustable along the necklace changes the position of the augmentation on the person (too high or too low). Thus, the marker will have be fixed on a specific part of the child’s upper body. Using face recognition and tracking (instead of image) or making a marker wearable on the child’s forehead are possible fixes to this problem.
4. Turn taking
   When a player has to wait for his/her partner to complete a task (some children finished coming up with their entities faster than others), he/she will get bored easily, leading to disinterest in the game. Thus, it is important that unnecessary idle waiting time is kept to the minimum during the game.

5. Game story
   The children were able to enjoy charades without a game story. Hence, at this stage, it is unimportant to get the ‘right’ story which blends in with the nature of the game (transformations etc.). Moreover, the story concept may be too complex or convoluted

when incorporated with charades. However, a loosely related storyline may help to band the players together so they can work as a team during the game.

3.4 Outcomes

The observation conducted have contributed to the understanding of the difficulties that arise when young children interact with one another during the charades game and AR app. Acknowledging that the size of test groups was limited in the studies, the design workshop concludes the following requirements:

1. The game should slowly increase confidence/comfort of children playing with one another for any acting out/role playing to be involved.

2. Keeping the other child waiting/guessing/at stagnant stage within the game generate disinterest and boredom. Thus, it should be kept to the minimum.

3. Children were excited with making others guess who they are. Hence, freedom in expressing/choosing who they are helps make the game more engaging.

4. Effectiveness of hangman type hints depends on the child's literacy level. Hence, the hint might be dropped from game design.

5. Humour bonded the children together faster than the game itself. Hence, it should be incorporated in the game to increase players' interactions.

6. Marker should be fixed in relation to player's movement and size.

7. Photo taking of augmentation session within app is appealing to the children.

8. Design techniques to encourage social engagement between players are important for players to be comfortable acting out and hence, for the game to be effective.

9. Game storyline does not have to fully support charades gameplay.

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 design 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.

4.1 DESIGN PRINCIPLES AND REQUIREMENTS

4.1.1 BASE GAME DESIGN [18]

The project is aimed at children with ASC (4-6 year old, Chapter 2.5.1) 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. 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 with his/her TD peer (4 year old and older, Chapter 2.5.1). Also, as there will be a TD peer involved, the game will have to be fun for the user group too. Hence, the interactive AR game should be effective, easy for the children to learn to use and fun from their 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 and peer support. To reiterate, pretend play refers to substituting an object/situation with another imaginary object/situation to satisfy one's personal needs and wishes for fun. Thus, the game app will be teaching the children via peer support how to perform substitution (transformation) of one's own identity to satisfy a need through charades gameplay.
   To encourage peer support, the game has to initiate and guide social interactions between the children while promoting other awareness in children with ASC (Wolfberg, et al., 2012) (Holt & Yuill, 2014). Efficiency measures how well the system supports the users in completing their tasks (Issa & Isaias, 2015). For example, the children should be able to complete their tasks in each round of charades in the simplest way possible i.e. by pressing a button.

[18] Some materials from my 2017 MInf 1 project, Peter's Adventures: A tablet app to elicit pretend play for Children with ASC

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 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, what the rules of the game are and what each game element on-screen represents.

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. Game acting as bridge for social connection between child with ASC and TD peer. By encouraging and maintaining positive social reciprocal effects (Chapter 2.2), the game can help enhance and support fun social engagement between the players.
   b. Use of unexpected elements and odd humour helps keep the interactions between player-to-player and player-to-game fun (Malinverni, et al., 2017) (Chapter 3.4).
   c. Giving the children the freedom to proactively choose what type of hints they want during charades. 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).
   d. By tailoring the themes of the game objects around things that get children excited.

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 and strategic reward system for two-player game i.e. maximising cooperative play (upcoming section 4.1.3).
    b. By disallowing any incorrect 'choice' within the game and thus, every decision has no negative outcomes. This is because children with ASC 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 (Bai, et al, 2015)
- Design guidelines from Bartoli et al on designing games for children with 'medium-low functioning' autism (Bartoli, et al, 2014).
- Cooperative play screen interface guidelines for children with ASC and their TD partner from Holt's and Yuill's study (Holt & Yuill, 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 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.

   According to Holt and Yuill, to encourage other-awareness during a two-player game, the game should have both the player's representations of their task states on-screen, control over their own elements but not their partner's, and having buttons which indicate an explicit joint agreement between both players during a task (i.e. 'We agree' buttons).

   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 difficulty with 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.

4.1.2 Previous Children Game Design Workshop

It is useful to learn from past experiences. Hence, the relevant design workshop requirements from past research[19] to increase enjoyment of an AR game app for young children are:

1. The game should include the child's object of high interest.
2. The game should have aesthetically pleasing design such as colourful items and animations.
3. Incorporate both themes of adventure and fighting against 'evil' guys as game play design.
4. Incorporate food, companion and aesthetically pleasing objects themes into the game environment design.
5. The game should include steps to introduce the child to the game concepts before making the game mechanics more open-ended.
6. Odd humour should be incorporated.

4.1.3 Cooperative Game Design Patterns (CGDP)

Since the game will involve a cooperative game framework between two players, effective cooperative game design patterns will be studied. Based on a research which analysed 14 successful published cooperative games for children (aged 6-16 year old), a group of

[19] From my 2017 MInf 1 project, Peter's Adventures: A tablet app to elicit pretend play for Children with ASC

researchers have identified (from experiments with 60 children) several effective cooperative patterns and lessons for future cooperative game designs (El-Nasr, et al., 2010). The 'effectiveness' reported in the study was measured by Cooperative Performance Metrics (CPMs) which consisted of measures such as laughter or excitement amongst players together, players working out strategies together, players helping each other, players waiting for each other etc. (El-Nasr, et al., 2010). The most effective set of patterns found were:

1. **Complementarity**
   As one of the most commonly used design patterns in cooperative games, complementarity ensures that the game characters controlled by players are different but complementary to one another (Rocha, et al., 2008).

2. **Shared goals**
   The pattern forces players to work together by giving a group of players a single quest with a shared goal (Rocha, et al., 2008). Thus, the success of a team depends on whether the team can accomplish a certain goal. This pattern also loosely aligned with the LEAP research whereby it was found that having interdependent reinforcement contingencies in a group setting helps increase engagement (behavioural improvement) of children with ASC (Strain, et al., 1985).

3. **Shared puzzles**
   Similar to shared goals, this pattern involves players encountering a shared challenge or obstacle together (El-Nasr, et al., 2010).

Moreover, as the child with ASC's learning preferences is unknown, to support positive social interaction between both players for peer support, a balance of didactic, instructional method will be used together with shared activities method during the game (Kasari, et al., 2016).

4.2 Low-Fidelity Prototype Design

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. Due to the complexity of gameplay, different parts of the game's design and structure was incrementally built over a series of expert's feedback. Thus, this section will contain two grouped[20] iterations of the initial draft game's design, expert's feedback and changes or further developments made on the game design. The full game design (high-fidelity prototype) will be finalised in section 4.3.

The usability goals [A1], [A2], etc. user experience goals, [B1], etc., system design requirements, [C1], etc. and CGDP goals [CGDP1], etc. are annotated later on in this chapter as reminders of some design justifications made.

4.2.1 Game Design Part I

At this stage, the game's framework is focused on determining how the two players would be interacting during the game and what the gameplay's dynamic would be. Thus, a game states diagram will be designed at the end of this section. Unfortunately, there are no literatures on charades being used to support pretend play in an AR game app. Thus, some initial ideas will

[20] Some game design decisions from experts' feedback made in parallel with experts feedback period. Hence, they might be presented before the reported expert feedback section.

be made into paper prototypes and then consulted with experts to help inform design decisions.

4.2.1.1 Gameplay Dynamic And Layout

The game app will consist of a tutorial and the main game consisting of 6 to 8 rounds of charades as introduced in Chapter 2.5.2. For each round, one player will be the mime and the other will be the guesser. The mime will have to act out or give hints to a random word he/she has picked. The guesser will have the guess the mime's word. The word will be from the animal kingdom category, a type of person category ('Who am I?' i.e. 'pirate', 'wizard') and magical creatures category. Hence, the word will also be referred to as the entity later on. Currently, there are two ways AR (visual hints) can be incorporated in charades as discussed in the design workshop chapter (Chapter 3.4):

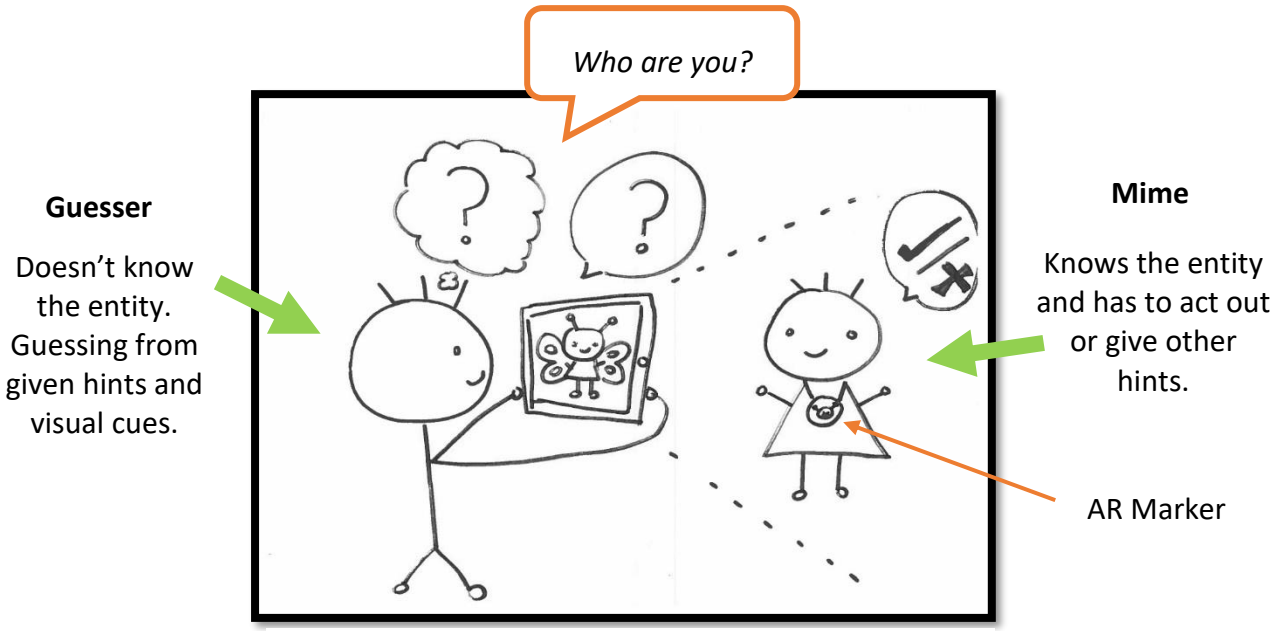

FIGURE 25. GUESSER (LEFT) AND MIME (RIGHT). THE WORD IS "BUTTERFLY".

A. **Hint alternative:** AR used as a visual hint altered to make it more difficult by limiting the number of objects augmented on the mime. As shown in Figure 25, the entity is "butterfly", hence, wings and feelers are augmented onto the mime who knows beforehand what the entity is. The guesser will have to guess the entity while the mime acts out (flap her arms) or give other types of hints until the guesser can guess correctly. To make it more challenging, the number of objects augmented on to the mime can be limited to one object i.e. only the feelers are shown.

B. **Support alternative:** AR used as obvious visual support during the round's entity reveal for the mime (at the start of round) or solution reveal for the guesser (at the end of round). Figure 26 shows how the game might look like should the AR be used as visual support for the mime at the start of the round. Another feature which can be incorporated into the game is letting the mime decide which entity he/she wants to have as shown in the left-hand side of the figure. As observed from the design workshop (Chapter 3.4), the children were excited to come up with their own entity and making others guess it. Hence, freedom in expressing/choosing the entity may help make the game more engaging.

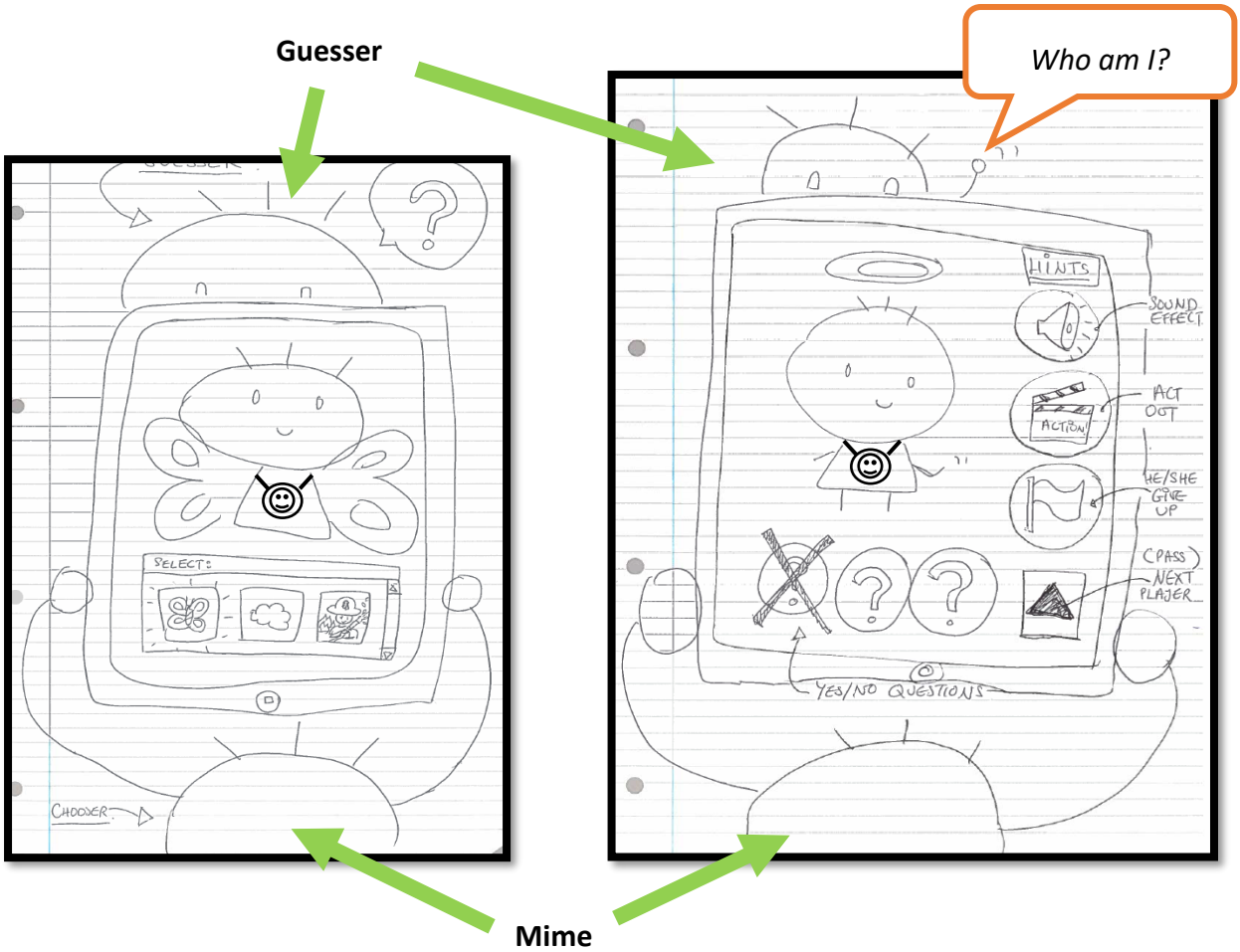

FIGURE 26. SELECTION SCREEN FOR CHARADES WORD (LEFT). AR AND HINTS SCREEN WHERE WORD IS "ANGEL" (RIGHT). NOTE: DESIGN IS NOT FINALISED AND IS SUBJECTED TO CHANGE.

The right-hand side of Figure 26 shows the hints panel layered on top of the AR rendering screen. Several hints and gameplay buttons are shown to keep track of and change game state:

a. <u>Sound button</u>
   When pressed, it means that the mime wants to give a sound hint for the entity. The hint was suggested by an expert (E2, next section) as a replacement for the hangman hint tested in the design workshop because it is easier for young children to make a sound of an entity than spell out a word.
   Game state: Sound hint being given
   Next state: Button no longer interactable

b. <u>Act out button</u>
   When pressed, it means that the mime wants to give an action hint (act out) for the entity.
   Game state: Acting out hint being given
   Next state: Button no longer interactable

c. <u>Yes/no questions button</u>
   When pressed, it means that the mime wants to answer a yes-or-no question hint for the entity. There are 3 of these buttons as observed from the design workshop, 4 or less yes-or-no questions hints is ideal (Chapter 3.4).

Game state: Yes-or-no hint being given
Next state: Button no longer interactable

d. Give up button
When pressed, it means that the mime does not want to give any hints or have already exhausted all the hints (all buttons not interactable) but the guesser is still unable to get the entity right. From the game design workshop, it was observed that the game should slowly increase confidence/comfort of children playing with one another for any acting out/role playing to be involved (Chapter 3.4). Moreover, the more natural flow of play is practiced to support socially coordinated play for children with ASC (Wolfberg,et al. , 2012). Thus, letting the players decide whether they want to give hints may ease them into the game.

Also, this prevents a losing state whereby the mime player lost to a round because he/she are unwilling to or unable to give good hints. This is so that no player decisions have negative outcomes [B3].
Game state: Mime gives up round
Next state: Next charades round for new entity

e. Pass button
When pressed, it means that the mime wants to pass the tablet to the guesser because the guesser wants to guess what his/her entity is. This is assuming that the game will be validating the guesser. Currently, this design is not efficient as there is a high chance the tablet will have to be passed back and forth a few times during a round. This increases the amount of motor control within the game which may lead to decreased usability for children with ASC (Dawson & Watling, 2000)(Chapter 2.5.5).
Game state: Mime passing tablet to guesser
Next state: Game validating whether guesser has guessed correctly (to be expanded in section 4.2.2-3).

Although the figures show the players wearing necklaces as markers, face recognition or headband markers will be considered for the game as they are more fixed to a player's movement.

4.2.1.2 Player's Roles

There are two possible ways the players are assigned roles within the game:

I. Assign the child with ASC the role of the mime and for his/her TD peer, the guesser. The roles will be it fixed throughout the game. The purpose of this is so that all the pretend play actions will be carried out by the child with ASC, focusing on his area of difficulty [A1].
II. Swap the roles of the players every round. Hence, both the children will become the mime and the guesser throughout the game. This may lead to a more balanced interaction between both players and hence, increase rapport.

The roles dynamic will be further discussed and decided upon with some experts in the next section for further clarity on the children's expected social behaviour outcome from each method.

4.2.1 Expert's Evaluation I

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 (Part I). Also, the aims, details and results of the interview sessions are discussed.

4.2.2.1 Aims

The aims of the interview sessions were:

1. To evaluate the appropriateness of the gameplay dynamic and the game tasks for the target group.
2. To evaluate the gameplay for encouraging pretend play in the target groups.
3. To evaluate the usability of the main game interface proposed.
4. To get further ideas for design plan improvements.
5. To revise and decide on a two-player game dynamic strategy that would be fun and effective for the target group.

4.2.2.2 Participants

TABLE 3. LIST OF EXPERTS IN EVALUATION OF LOW-FIDELITY PROTOTYPE

Expert	Background
E1	University professor with research background in technology for behaviour change design, development and evaluation of serious games for education and health with children.
E2	Research postgraduate student researching in multi-player game applications for young children.
E3	Research postgraduate student researching in pretend play AR app for children with ASC.

4.2.2.3 Materials

The AR app developed on the Samsung Galaxy tablet from the design workshop and the marker were used (Chapter 3). The game structure design sketches were used to show the game design plans.

4.2.2.4 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 the previous section via sketches. Then, the AR game app from the design workshop was shown to them together with the marker. Also, some design workshop requirements were presented (Chapter 3.4). 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.

4.2.2.5 Feedback

1. Appropriateness of players' dynamic during game
   a. *Gameplay*

      All experts agreed that having AR as visual support for entity reveal is better than as visual hint. E1 reasoned that it does not add to the pretend play element of the game to have children guess the 'costume' of the other player. E2 reasoned that having the visual support dynamic (reveal of entity to the mime at the start of the round using AR) creates a more natural gameplay. Additionally, E2 advised to not keep the guesser disengaged for long while the mime chooses his/her hints from the interface; the game has to constantly be engaging for both parties. Thus, the amount of time during which one child picks up the tablet should be limited.

      Also, E2 suggested having the tablet in between two players sat across each other as its default position so that both children can be involved in the game, increasing engagement by emphasising the shared space between the players. Moreover, E2 commented that when one player gets excited, it will most likely cause a positive reciprocal effect on the other player. Thus, supporting a high level of engagement between players is important.

      E3 advised that structure and rules make it simpler for younger children with ASC to understand the game. Turn taking structure should be clear by gauging what the players would say to each other during the game. Additionally, E3 recommended that different rewards should be given to children with ASC and TD children. Lastly, E1 advised analysing mainstream multiplayer apps for children to find useful design features.

   b. *Player's Roles*

      E1 stresses that children value fairness when they play alongside each other, thus, it would be better if both child with ASC and his/her TD peer can play both roles throughout the game as the mime or as the guesser. Both E2 and E3 suggested scorekeeping and competition between players to increase the children's engagement and interaction. Also, E2 recommended getting the players to type out their names at the start of the game.

2. Main game effectiveness, usability and tasks
   a. *Effectiveness*

      E2 and E3 agreed that the children can pick up pretend play skills from the game. On the other hand, E1 commented that the game design was more of a logic game (deducing entity based on hints given) than a game of pretence. However, the game is divided into two roles: the guesser of the game will need to be thinking logically to correctly solve the entity while the mime has to mimic the entity via actions (or sound) which is a form of pretend play as the child is transforming his own identity into the entity's identity for that moment.

      E1 suggested changing the game design into an AR tool to aide free play sessions to support pretend play. This way the children have complete choice over their play and imagination. However, E3 warned children with ASC may have more difficulty with free play but agreed with E1 that supporting the children's free play with AR

helps with pretend play. E2 suggested having more markers to augment like a marked block (something for the children to hold) so that the player can play with the augmentations on screen.

b. *Usability*
E2 commented that children love visual objects and that AR would make the game more fun for them. E3 added that using headbands for the markers would be good.

c. *Game tasks*
E2 suggested adding sound hints into the types of hints for the mime player to give. This is in response to the design workshop observation in which hangman was found to slow down the game's pace and increase the likelihood of the children being less engaged with the game (Chapter 3.4). E3 added that giving contextual hints (i.e. a ship and the sea for the entity "pirate") will also teach the children to recognise the context associated to the substitution objects within pretend play.

4.2.2.6 Discussion

There was a great deal of constructive 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. *Different rewards should be given to children with ASC and TD children*
Although different rewards can be chosen by the children at the start of the game so that they will be more excited to play the game, there was not enough time to implement the feature. Instead, the project has been focused on improving the game dynamic for two players (turn taking, social bond etc.) via CGDP methods such as shared goals. An alternative type of reward for children with ASC (rotating animation on game object) will be implemented [B3][C2].

2. *Changing the game design into an AR tool to aide free play sessions*
The aim of the project is to create an educational game app which provides a structured environment for the children with ASC and his/her TD peer to play in with as little support from adults as possible. It will also be encouraging peer support by guiding the social interaction between the players via rules and common goals. Although it is a good idea, changing the game design into a free play tool design is out of the project's scope. However, it will be added as an extra feature of the game and covered in future work.

3. *Have more markers to augment like marked blocks for children to hold*
Integrating this into the current charades game design will lengthen the amount of time one player holds the tablet while the other player wearing the marker waits. This is not encouraged as children get disinterested easily when they are idle (from design workshop Chapter 3.4 and E2). However, this will be added to future work as it can be integrated into other AR games design.

4.2.2 Game Design Part II

This section finalises the design decisions discussed in the previous design section (4.2.1). The feedback from the experts are integrated into the game framework and the game design is built up on with more details. Development of the game app has started and design decisions for it will be discussed. Then, the developed game plans and app prototype will be evaluated with a second set of experts to improve the overall game design. For the rest of the paper, the charades game will now be called **GuessMe** to distinguish between the typical charades game and the project's altered version of it.

The IPG's conceptual model of guided participation will be followed closely in this section to ensure that the child with ASC is appropriately supported and will benefit from the game and his/her TD peer. The main practices which will be integrated into GuessMe are nurturing play initiations, scaffolding play, guiding social communication and guiding play in the Zone of Proximal Development (Wolfberg, et al., 2012). A balance of didactic instructions and shared activities will be maintained to accommodate for children with ASC who have different personalities (Kasari, et al., 2016).

4.2.3.1 Players' Dynamic in Game

In order to clearly show the steps within a round of the game, a storyboard-like diagram was drawn to mark out (green circle) which participant (players and tablet) is playing an active role during the game (Figure 27). This is to highlight turn taking steps within the game and the possible dialogue between the players. Also, the diagram shows how the tablet will be handled during the game. As per expert's advice, the game will be focusing on creating a shared space between the players by having the tablet laid between the players as its default position. This strategy also increases other awareness (Chapter 2.5.5) by increasing eye contact between the players and minimising the time a player spend blocking out the other player with the tablet.

Step 1: Players sit across each other with the tablet in portrait orientation between them. This is so that when one of the children picks up the tablet to view the augmentation, it would already be in portrait orientation without having to turn it (preferred over landscape, Chapter 3.4). This decreases the amount of motor skills needed to play the game and make it easier for children with ASC [A4] (Chapter 2.5.5).

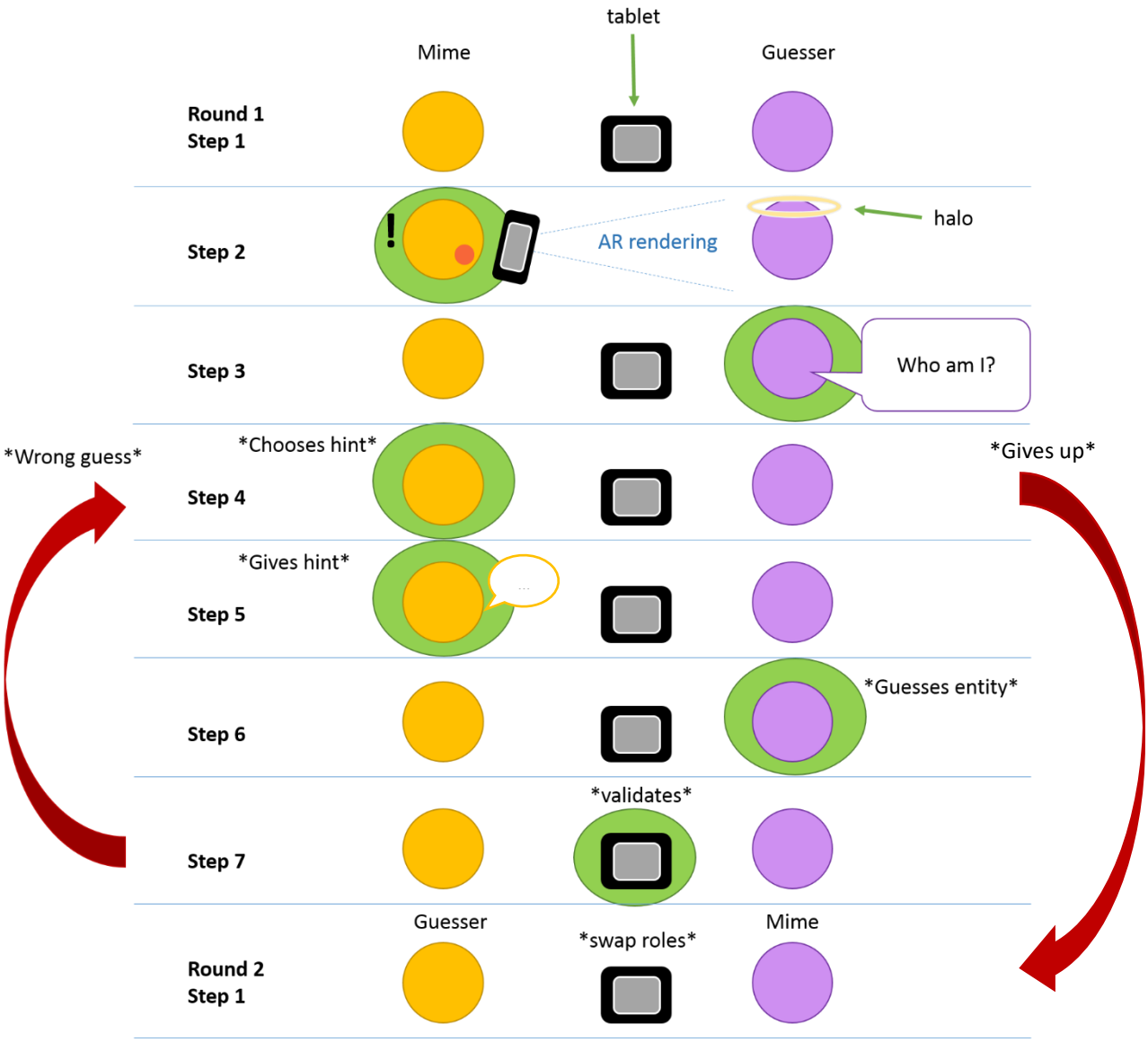

FIGURE 27. DIAGRAM TO SHOW DETAILED GAMEPLAY FOR ONE ROUND OF GUESSME

Step 2: The mime picks up the tablet and views the augmented guesser. He/she knows the identity. If the player is unsure, more information will be given [A3].

Step 3: The mime puts the tablet back down and the guesser asks the mime "Who am I?".

Step 4: The mime chooses the type of hints he/she wants to give the guesser. The hints may be sound, contextual, acting out or answering yes-no questions. If the mime does not want to and 'gives up', the game skips to the next round. There may be support needed for players who do not know how to give a certain hint (i.e. a video of the entity if the mime doesn't know how to act out etc.). This will be discussed with the experts later on.

Step 5: The mime gives the hint to the guesser.

Step 6: The guesser guesses the entity.

Step 7: The tablet validates the guesser and says whether he/she was right or wrong. If the guess is wrong, the game goes back to step 4. It is yet to be determined how the game would validate the guesser. This will be further discussed with the experts in the next section.

Step 8: If the guesser was correct, the game switches the roles of the players and starts the next round.

The current diagram model shows that the dynamic between the players during the game is unbalanced. The mime is playing a more active role from step 2 to step 5. This may cause boredom or disinterest in the guesser. Hence, the gameplay mechanic will have to be altered to accommodate more turn taking between the players. This issue will be worked on for the next iteration of the game design (section 4.3).

4.2.3.2 Game Development: Design and Layout

A. AR Markers

Headband markers were chosen over face recognition mainly due to cost. Unity's OpenCV[21] asset, which is required for face detection and code-from-scratch image processing algorithms, needed to be purchased in order to be used. An advantage headbands,Figure 28, have over face recognition is that they are tangible representations of the character roles the children will be taking over during the game. Hence, they serve as a reminder of which character their partner is representing (when a child looks at his/her partner wearing the headband) [A5].

FIGURE 28. HEADBANDS WITH MARKERS SEWN ON THEM

The markers' theme was loosely based on superheroes which was suggested by the children in design workshop [B1]. Superheroes tend to wear a simple symbol on themselves i.e. 'S' for Superman, a spider for Spiderman, green lantern for Green Lantern, planet for Captain Planet etc. Hence, a fire symbol and a water symbol were chosen. Also, they represent opposing but complementary forces [CGDP1]. Both markers were outlined with their respective colours, yellow for fire element and purple for water element. This is based on the assumption that children are used to cartoon characters being differentiated by their colours (i.e. in Teletubies, Power Rangers, Sesame Street and Teenage Ninja Mutant Turtles) because different colours are easily distinguishable.

[21] https://assetstore.unity.com/packages/tools/integration/opencv-for-unity-21088

FIGURE 29. POPULAR CHILDREN SHOWS WITH GROUP OF MAIN CHARACTERS BEING DIFFERENTIATED BY COLOURS[22]

Moreover, taking E1's advice into account, a popular (10,000 installs with 4.1/5 rating from 455 reviews on Google Play Store) multiplayer children game app was analysed (age rating is 2+)[23]. Marble Mixer is a game involving players (maximum 4 players) flicking marbles into a moving hole in the middle of the screen. To register each player, the game lets the users click on 'Join' buttons at each corner of the screen (for example, green and purple players in Figure 30). The players were screen-space and colour differentiated for ease of use (each player positioned at that corner of the screen) and simplicity (colour differentiation of players). Hence, for GuessMe, the players will be registered as characters distinguishable by colours. Screen space differentiation will be discussed in the game layout section.

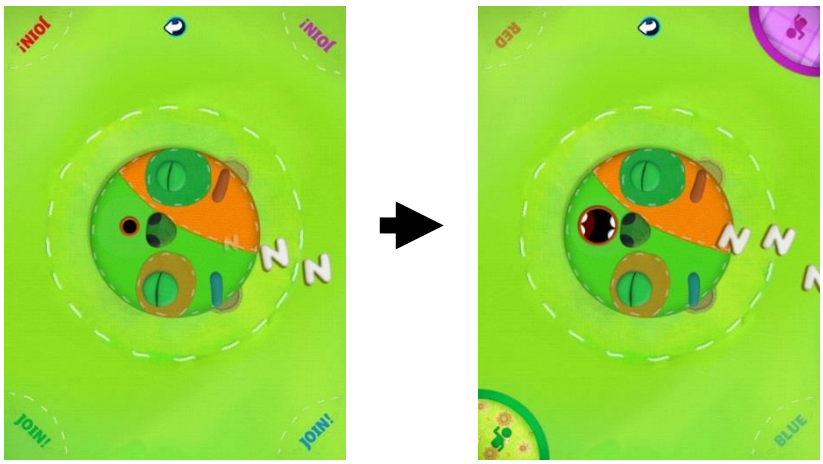

FIGURE 30. MARBLE MIXER APP'S PLAYER REGISTRATION INTERFACE WITH ACTIVE GREEN AND PURPLE PLAYERS[22]

B. Narration Voice

An online Text-To-Speech (TTS) converter tool with the most natural sounding voice was used to optimise players' comprehension [B2]. The digital speaker used was a 'British English' accented middle-aged man's voice. All the sentences in the game script were tested and

[22] Sesame Street, http://kidscreen.com/2014/11/27/chromecast-adds-sesame-street-nickelodeon-content/

Teletubbies, https://www.bbc.co.uk/cbeebies/shows/teletubbies

Teenage Ninja Mutant Turtles, http://xboxenthusiast.com/2015/11/30/is-platinum-games-developing-a-teenage-mutant-ninja-turtles-game/

Power Rangers, http://powerrangers.wikia.com/wiki/File:Zeo_rangers.png

[23] Marble Mixer game app, https://play.google.com/store/apps/details?id=com.realarcade.MP&hl=en_GB

carefully edited to remove incorrect or unnatural pronunciations and unnatural pauses in the sentence. The scripts will be shown in the following section.

C. Game Menu And Players' Names Screen

The game menu, Figure 31, consists of 4 buttons with easily recognisable icons which map to their functionality respectively [A4]:

- 'Start' button: Starts the introduction and tutorial of the game. It is aimed at new players.
- 'Play' button: Starts the main game for players who already went through the tutorial.
- 'Score' button: Shows the scores of each player.
- 'Pics' button: A free play mode whereby players can choose which random augmentations they want to put on themselves or peers and take pictures. This is just a side game mode and possible expansions for it is out of scope of the current project. Thus, the mode is just for the children's entertainment.

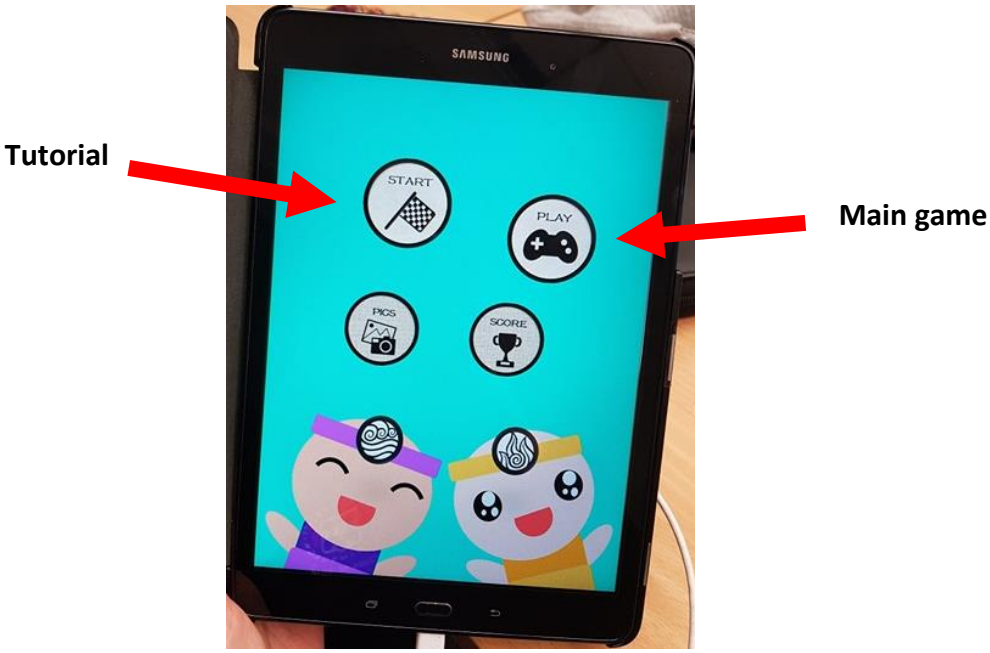

FIGURE 31. GAME MENU

The buttons are all big so that they are easily used by children with developing motor skills [A2]. Also, they are neutrally coloured to lead the players' attention to the more colourful game characters on the screen. This is to make sure that the children become slowly accustomed to the main characters which will be presented throughout the game, giving the child with ASC a sense of repeatability and predictability in the form of familiar characters [B2][C1]. Throughout the game, the only screen interface interaction the children will have is to press buttons as it is the most intuitive gesture for young children [C3].

Once 'Start' button is pressed, the players will be taken to the name input page whereby they are assigned their respective agents (Figure 32). This ensure that some form of communication and agreement between the children has been made to decide who wants to be which character [A1]. The screen interface for the rest of the game will be following the SCoSS design whereby each player has his/her own screen space with a consensual button for each player to increase other awareness in children with ASC (Holt & Yuill, 2014). The player who is Agent Purple will always have the upper half of the screen while the player who is

Agent Yellow will always have the lower half of the screen. The consensual buttons are brightly coloured [C4] and is respective to each player's agent's names so that the children will always know which buttons are theirs to press [A1].

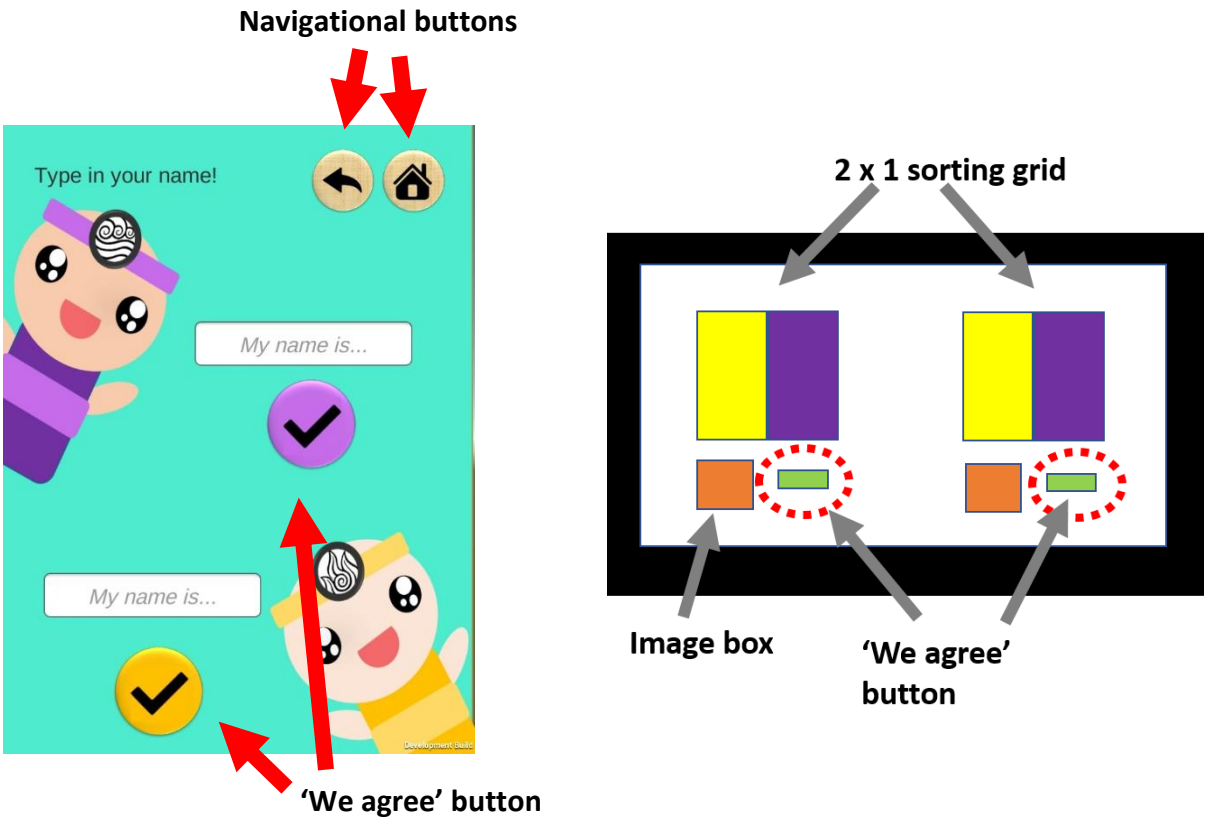

FIGURE 32. SCREEN TO INPUT PLAYER'S NAME (LEFT) AND SCOSS INTERFACE (RIGHT) (HOLT & YUILL, 2014)

When each consensual button is pressed, a variation of fart sound (according to each player) is played as touch input feedback [C6]. This adds humour and oddity to the game which is likely to facilitate social initiation between players and increase their comfortability with each other so that they will be at ease to act out in front of their peer later on (Malinverni, et al., 2017) (Chapter 3.4). The game will only process to the next screen once both players have pressed their respective consensual buttons. This is to ensure that both players understood the given instruction by not allowing one player to skip the audio without the consent of the other player [A2][C6].

The navigational buttons are neutrally coloured just like the menu buttons to draw the children's attention to the main game. This is to reduce the amount of attention grabbing objects on screen and thus, reduce sensory overload which children with ASC are prone to [C2]. The buttons allow the children to either go back to the previous screen or to the home menu [A2]. In this case, both buttons will return the players back to the menu screen. Although they are redundant, the game aims to increase predictability and familiarity even for the use of its navigational interface [C1]. Hence, the buttons will be present in all of the introduction screens.

The script for Figure 32 (Left) is as follows:

- ***Screen instruction:*** *Hello! To start, each of you will have to pick which agent you want to be. Then, type in your name and press the button below.*
- ****Purple button pressed*:*** *Your nickname is now Purple.*
- ****Yellow button pressed*:*** *Your nickname is now Yellow.*

As shown from the script above, the narrated instruction is concise to hold the attention of the players [C6]. It is didactic and instructional as some children with ASC benefit from this method of teaching (Kasari, et al., 2016). By giving the players their respective agent's nicknames, the game will be able to address each player directly. This helps the game give guidance to each child later on (scaffolding play), supporting children with ASC's play with their peers (Wolfberg, et al., 2012).

D. Game Tutorial and Interface

The game's tutorial is in development at this stage and is completed in a rough paper prototype as shown in Figure 34. A game story will be created later on to give the players a shared goal. The current tutorial prototype is subjected to major changes as it is not concise and simple enough for children's comprehension. The game's tutorial will be explaining the following information:

1. The overarching goal of the game.
2. How to position oneself to play the game.
3. What are the categories of the GuessMe entities?
4. What are the rules of the game?
5. What to do for each hint?
6. What are the players' respective roles for each round of the game?
7. When to hold up the tablet?
8. How will the players be scored?

Figure 33 shows a part of the tutorial which explains information 1 and 2 respectively. The script for the screens is as follows:

- ***Left screen instruction:*** *The goal of the game is to earn as many tokens as possible.*
- ***Right screen instruction:*** *Now, sit across each other.*

The left screen clearly marks out each player's colour coded 'table' (purple and orange panels) which separates the player's respective spaces. Then, in the right screen, purple's table is

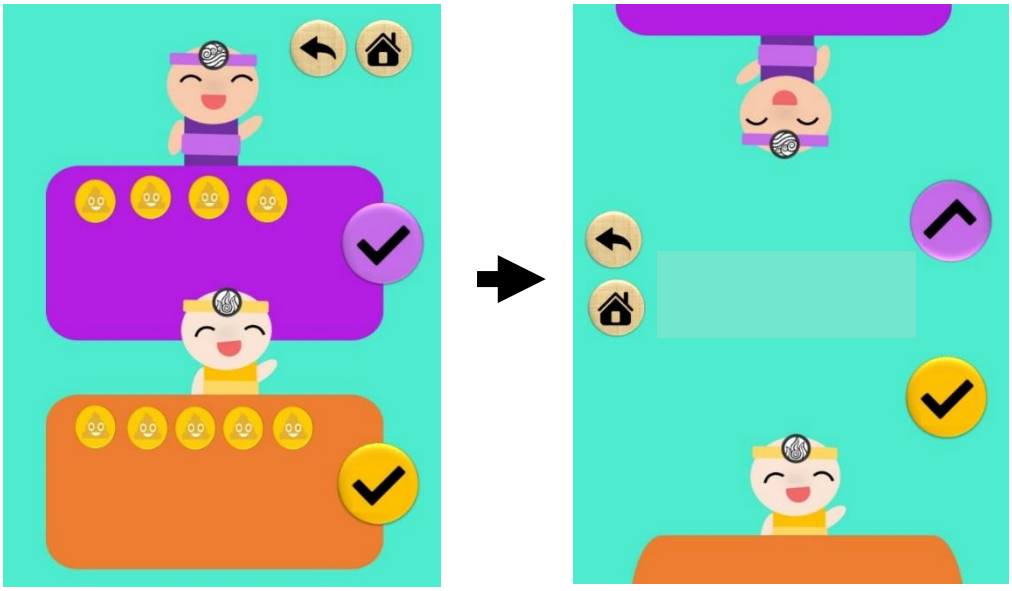

FIGURE 33. TUTORIAL EXPLAINING OVERARCHING GOAL (LEFT) AND PLAYERS' POSITION (RIGHT)

rotated to direct the player to his/her end of the tablet. This is to slowly ease the players into the face-to-face position planned out earlier on where the tablet is in-between the players [A4][C1]. The navigational buttons had to be moved to the left to allow space for the change.

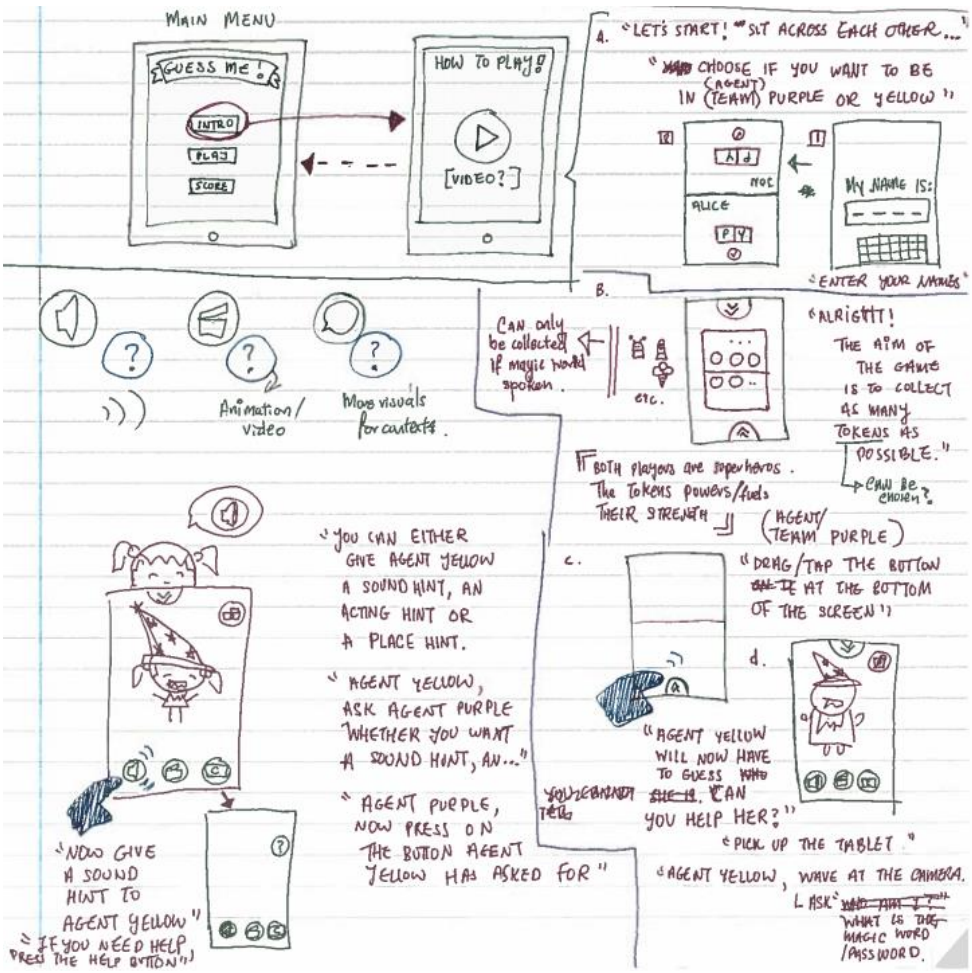

FIGURE 34. INITIAL DESIGN FOR GAME TUTORIAL TO BE REVAMPED

Golden poop token was chosen as reward for each round of GuessMe because they were meant to add humour to the game [B1]. This was, however, changed later on in the final version of the game.

The right screen of Figure 33 follows the design of the Marble Mixer[24] game app whereby the game elements of each players are constantly shown (buttons, players and panels) and are orientated according to player's positions around the tablet (Figure 35) [A3].

FIGURE 35. ONGOING GAME WITH TIMERS AT THE TOP AND BOTTOM OF THE SCREEN ORIENTATED FOR EACH PLAYER (LEFT). ORIENTATED SCORE BOARD SHOWN FOR EACH PLAYER WITH RESPECTIVE 'OK' BUTTONS.

Tutorial development was paused here due to time needed to figure out how to introduce the game elements to the players. An attempt was made, Figure 36, where Agent Yellow will be taught what each hint buttons do (sound, action, contextual, yes-or-no questions). However, a strategy has not been found to explain the game elements to each player on their respective 'tables' while keeping both players engaged by not spoon feeding them the obvious information (action icon means acting out etc.) as it may cause boredom and disinterest especially for the TD child player. Moreover, the IPG model also favoured finding the right amount of support without hindering the natural flow of play for children with ASC (Wolfberg,et al. , 2012).

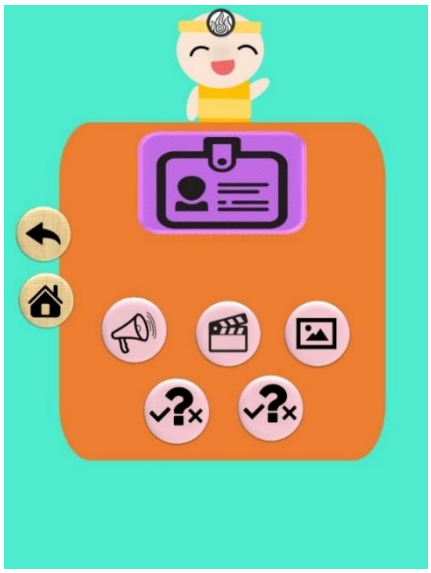

FIGURE 36. ATTEMPT AT DESIGNING A TUTORIAL SCREEN TO EXPLAIN EACH TYPE OF HINT.

[24] Marble Mixer game app, https://play.google.com/store/apps/details?id=com.realarcade.MP&hl=en_GB

4.2.3 Expert's Evaluation Part II

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 (Part II). Also, the aims, details and results of the interview sessions are discussed.

4.2.4.1 Aims

The aims of the interview sessions were:

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

4.2.4.2 Participants

TABLE 4. LIST OF EXPERTS IN EVALUATION OF LOW-FIDELITY PROTOTYPE

Expert	Background
E4	Research associate professor with main research interests in Human-Computer Interaction, digital learning, multimodal Interaction, assistive technologies, educational technology and technology for autism.
E5	E-learning professor who has a grandchild with ASC. He specialises in learning technology and human response to technology with interest in educational technology for children.

4.2.4.3 Materials

The introduction section of the game app was developed on the Samsung Galaxy tablet together with the main menu navigational scene and the game tutorial developed so far. Also, the AR app used in the design workshop altered to detect the markers on the headbands were used for viewing purposes. The game structure design sketches were used to show the rest of the game design plans.

4.2.4.4 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 the previous design section via sketches. Then, the introduction/tutorial of the game app was shown to them together with the marked headbands. Then, their feedback on further game plans and game tutorial was 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.

4.2.4.5 Results

1. Appropriateness of players' dynamic during game

a. Gameplay

E4 warned that children with ASC may have difficulty passing the tablet to his/her peer while viewing the AR. Similarly, E5 cautioned that children with ASC may have difficulty with turn taking, hence, design strategies should be used to encourage the behaviour. Overall, E4 advised reducing the amount of time spent on unnecessary steps in the game so that the game does not get overcomplicated for young children which may lead to disengagement.

b. Player's Roles

E4 suggested creating a "Guess Who Am I" button to let the guesser press when he/she wants to be validated. Then a multiple choice question will be shown with 4 to 6 choices. However, the child may randomly pick one and gets it correct so the idea may need some revision.

Also, she questioned how the game will prevent the mime from giving the answers outright to the guesser while E5 warned against competition (player with most tokens wins) for motivating children to engage cooperatively. The idea of soft competition in the game was discussed whereby the players keep their respective number of tokens earned but the sum of their tokens contribute to a greater cause. This way, their individual performance in the game can be reflected on to prevent collusion while still giving them a sense of cooperation. This also aligns with the shared goals CGDP and research done to aide social behaviour in children with ASC within classroom settings (Strain, et al., 1985) (El-Nasr, et al., 2010).

E5 believes that the mime giving the guesser the entity answer straightaway is unlikely to happen because it is not in children's nature to deceive a game. Hence, he suggested focusing on more on social engagement and cooperation between the children than their achievements in the game.

2. Main game effectiveness, usability and tasks

a. *Effectiveness*

Both experts agree that GuessMe can help children with ASC with social interaction and pretend play through turn taking (if done right), using AR as visual support and acting out various entities. E5 questioned the use of golden poop tokens looking like coins as children with ASC are unlikely to be motivated by monetary objects.

b. Usability

No issues were raised with the current game prototype. Moreover, E4 helped with the main game's rough storyboard by talking through it (Figure 37). Further details on design will be discussed in the next section.

c. Game tasks

E4 likes the yes-or-no hint type because it makes the game more "game-like". Also, she recommended disabling the hint button's interactivity after the hint has been used.

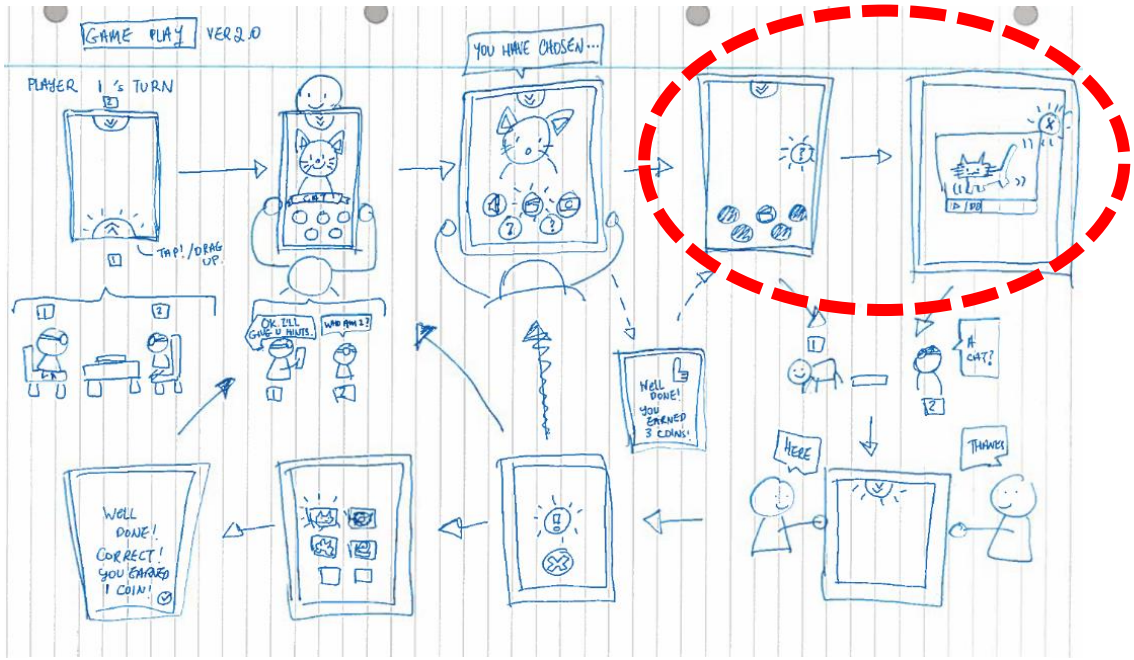

FIGURE 37. ROUGH RE-SKETCH OF GAME STORYBOARD DISCUSSED WITH EXPERTS.

3. *Further improvements*

E4 suggested implementing versions of the game with more hint support for beginners and less hint support for advance players. Also game versions letting the mime choose the entity or not can be implemented. This is so that during the evaluation workshop with TD children, conclusions can be made on which features are beneficial.

4.2.4.6 Discussion

There was a great deal of constructive 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. *Creating different versions of the game for evaluation*
   There is limited time within each planned evaluation session (30 minutes). Thus, there will not be enough time for the children to play through different versions of the game to give feedback on which versions are better. One version of the game will be evaluated and improvements needed for the game will be inferred from observation. Thus, this suggestion has not been followed through although it is helpful.

2. *Design feature discussed from encircled area in game storyboard, Figure 37*
   One feature discussed with E4 was to give help for children struggling with giving hints using videos. Although this seem like a helpful feature, due to time limitations, videos could not be collected for all types of hints (i.e. magical unicorn) without it infringing copyrights. Hence, to upkeep with the game's consistency, this feature was not implemented. This design idea will be added to future work chapter.

4.3 High-Fidelity Prototype

Different aspects of the game may be interwoven in each section so that design justifications will be concise but within context.

4.3.1 Game Story

As discussed with the experts, to set up soft competition, the players will need a common goal. A story was crafted to briefly introduce the game characters and give the players a purpose to band together and perform within the game.

FIGURE 38. GAME INTRODUCTION STORY SCENES

The game story scenes (Figure 38) were added after the screen where the players are registered with their names (Figure 32). Odd humour, surprising and unexpected elements (i.e. Poopzilla, sushi) were incorporated to facilitate social initiation and bond between players (Malinverni, et al., 2017)(Chapter 3.4). Moreover, the game requires both players to individually collect as many sushi as possible to feed Poopzilla together. This is to encourage behaviours related with social requests, a cooperative game mechanics (both) where resources are distributed between players to achieve a common goal was used (Malinverni, et al., 2017)[CGDP1] [CGDP3]. Scene 4 emphasise the theme of "cooperation to win" by giving both characters heroes' capes and highlighting (in red) their hands clasped together [A1]. Additionally, the characters were described in the story as 'best friends' to soften competition

by injecting artificial bond between the characters the children will be playing as. The script for the scenes is as follows:

Scene 1: *Agent yellow and purple are best friends from the same village.*
Scene 2: *One day, as they were playing outside, a monster called Poopzilla came stomping into their village.*
Scene 3: *He was very hungry. He growled, "If you don't give me sushi, I shall destroy your village!".*
Scene 4: *Agent purple and yellow decided to team up to get a lot of sushi for Poopzilla.*

The vocabulary was kept simple and the sentences were short and concise for young children aged 4 (minimum user age). To be noted, the golden poop tokens were replaced by sushi.

The following section describes GuessMe's gameplay together with the design decisions. However, some game elements design will not be covered as it will be expanded later in section 4.3.3. The game tutorial will be covered in section 4.3.4.

4.3.2 Revised Gameplay

Some gameplay dynamic design was changed to increase turn taking between the players and increase engagement (less waiting time for any player). As shown in the revised gameplay diagram below, Figure 39, there is a more balanced dynamic between players. From step 3 to step 6, both player roles are interacting with one another and are equally active (green circle) throughout the round. The dialogues expected between the players will be guided via audio scripts addressing the players (shown below). In this case, guiding social communication (IPG practice 3) helps children learn how to maintain play interactions (Wolfberg, et al., 2012). Moreover, complementarity of the roles are emphasised through hint requests and guess validations [CGDP1].

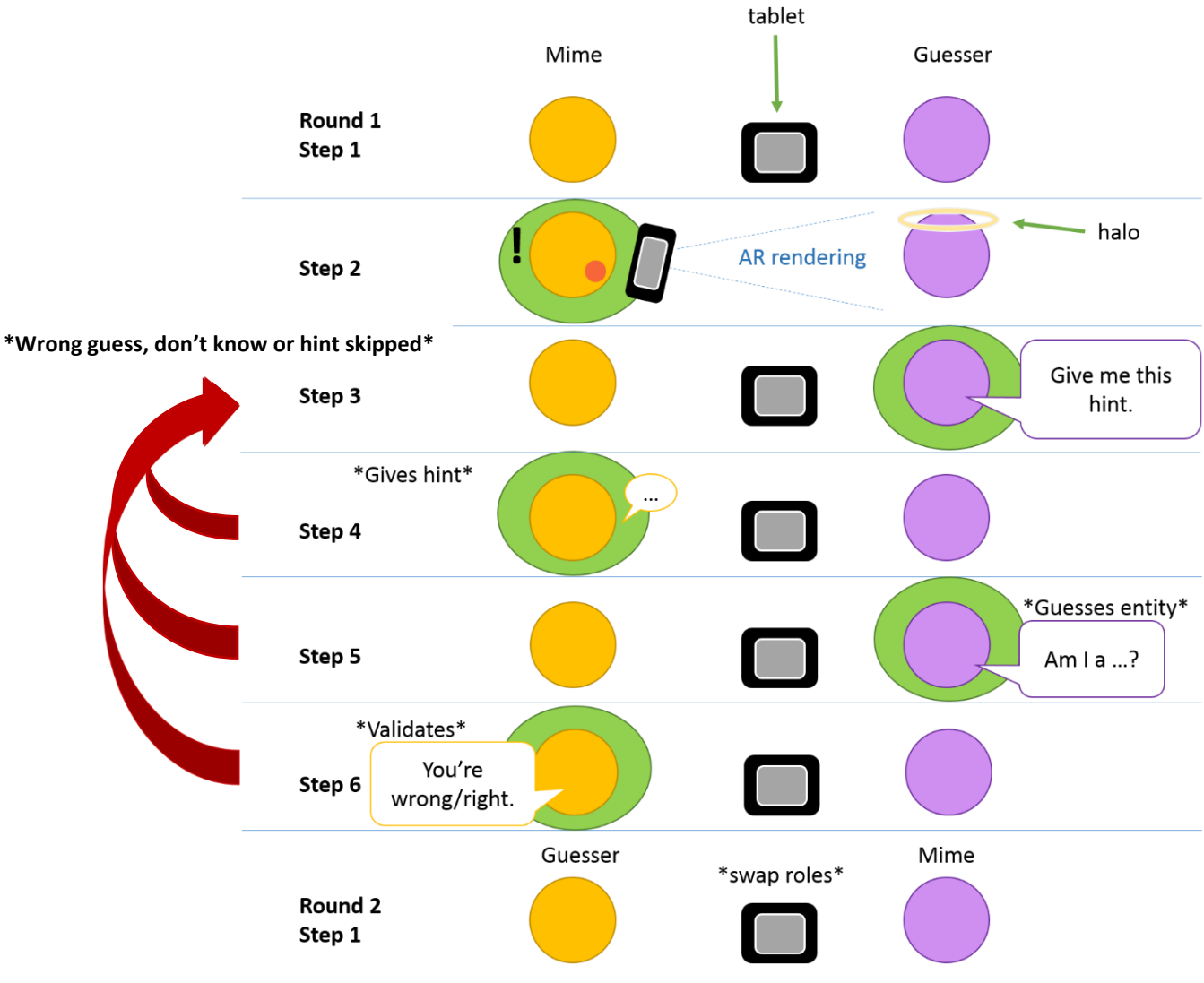

FIGURE 39. REVISED DIAGRAM SHOWING DETAILED GAMEPLAY FOR ONE ROUND OF GUESSME

Step 1: Players sit across each other with the tablet in portrait orientation between them.

Step 2: The mime picks up the tablet and views the augmented guesser. Now, he/she knows the identity. If the player is unsure, he/she can press the help button encircled in Figure 40 for confirmation [A3]. A picture of the entity with its text will be shown. Using visual reinforcement as a 'Help' feature has been recommended for preschool level literacy users [C2]. Also, the picture serves to help the child with ASC map the resemblance between his augmented peer and the entity. All help buttons throughout the game will be blue with a question mark to keep the button consistent and representational by following the standard convention [C5].

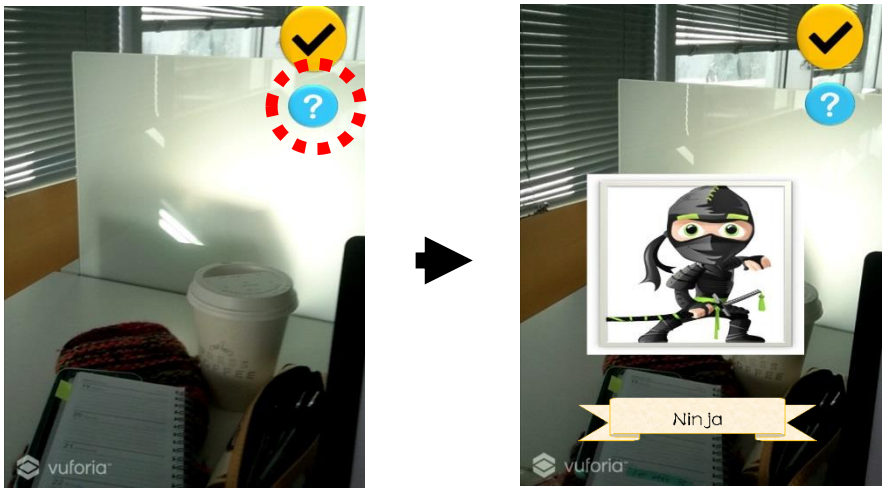

FIGURE 40. STEP 2 SCREEN: HELP BUTTON FUNCTION

> ***Script for step 2:*** *Alright, yellow, hold up the tablet to see purple's secret identity. You cannot tell purple who he is. When you are done, put the tablet back on the table.*

After every 10 seconds, the audio will repeat "*Once you know the secret identity, click the OK button*" to encourage the child with ASC to put down the tablet (turn taking). Also, the audio helps to notify the guesser that the mime's turn may be up, encouraging a request from the guesser to have his/her turn. This feature tackles a possible issue pointed out by experts (E4 and E5) whereby the child with ASC may not hand over the tablet.

Step 3: The mime puts the tablet back down and the guesser chooses the type of hint he/she wants from the mime. In the case of Figure 41 (left), the guesser has chosen the sound hint (encircled). The selected card (together with its help button) is animated to travel downwards to the card placeholder on Agent Yellow's table and rotates [C2]. The script for each help button is as follows:

> ***Script for step 3:*** *Put the device down. Now, purple will choose the type of hint he wants yellow to give.*
>
> ***H1:*** *Act out the identity.*
> ***H2:*** *Make the sound of the identity. **Or say a sentence that the identity would say. (** only in tutorial)*
> ***H3:*** *Describe the identity in a sentence.*

H4: *Get asked a question with a yes or no answer.*

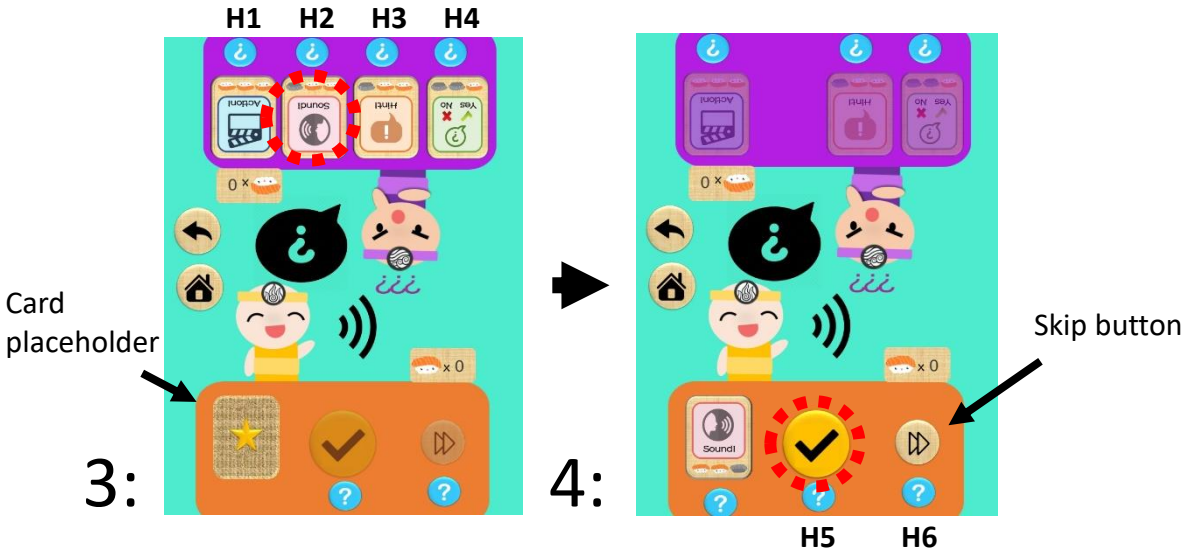

FIGURE 41. PICKING TYPE OF HINT AND DOING THE HINT: STEP 3 TO STEP 4

Again, the player is reminded to put the device down to support the possible issue mentioned earlier. The script is in third person as it is addressing both players so that "Agent Yellow" will also know that he/she will have to give the hint later on. No audio will automatically describe what each type of hint is. Instead, the player will have to press the help button below each card to get its description.

Step 4: The mime gives the hint to the guesser and then press the OK button encircled in Figure 41 (right) which signifies hint has been given. The skip button beside it signifies that the mime does not want to give the hint [B2]. Pressing the button brings the game back to step 3. The button is neutrally coloured to subtly discourage skipping. The script for each button is as follows:

H5: *When you have given the hint, press this button.*
Script for step 4, OK button: *Well done! Yellow has earned sushi!*
H6: *If you want to skip, press this button.*
Script for step 4, Skip button: *That's alright. Try again*

FIGURE 42. SUSHI EARNED ANIMATION

When the OK button is pressed the mime will be rewarded and praised (i.e. "Well done!") for giving the hint. As shown in Figure 42, a rotating animation containing a sushi with the score[25] will be played together with an audio of children cheering. Children with ASC were observed to respond well to dynamic stimuli (animation and cheering audio) because the features increase motivation and make the game more enjoyable (Bartoli, et. al, 2014) [B3] [C2]. The positive feedback is to reinforce positive game behaviour (i.e. giving hints). Also, the game uses positive encouragement to motivate players who 'failed' to try again. This is so that the players do not lose confidence and disengage from their peer or the game.

Step 5: The guesser guesses the entity. If he/she does not know the entity, the red button (Figure 43, left) is pressed and the game goes back to step 3. Otherwise, the green button is pressed to signify the guesser knows the entity and the guesser tells the mime what his/her guess is. Both red and green buttons are vibrant to highlight the common assumption of the colours (positive for green and negative for red) so that they are intuitive to use [A4]. The script for each button are as follows:

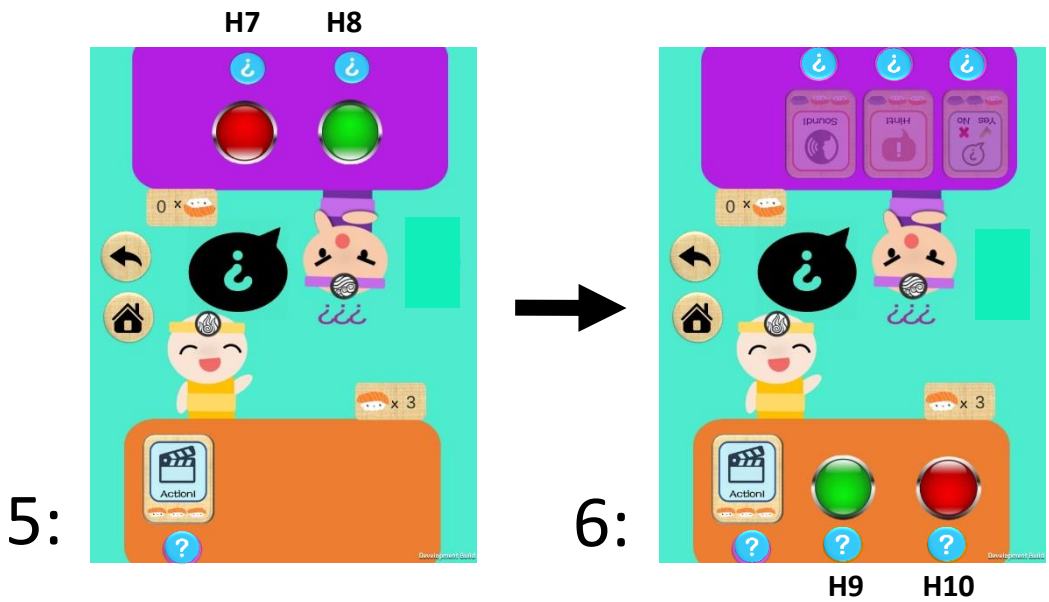

FIGURE 43. GUESSING AND VALIDATING: STEP 5 TO STEP 6

Script for step 5: *Now, can Purple guess his secret identity? **If you know press the green button, otherwise, press the red button. (**only in tutorial)*
H7: *I still don't know my identity.*
Script for step 5, Red button: *That's alright, try again.*
H8: *I know my identity.*

[25] Number of sushi earned which corresponds to the hint card

Script for step 5, Green button: *Yellow, was Purple correct?*

As shown, the game directly asked each player by addressing their game 'nicknames'. This guides social communication and thus, help the children learn the play interactions within the game (IPG model practice 3).

Step 6: The mime validates the guesser's guess by pressing either the green button for 'correct' or red button for 'wrong' (Figure 43, right). If the red button is pressed, the game goes back to step 3. If the green button is pressed, the sushi score animation (1 sushi) as represented in Figure 42 plays (with the kids cheering audio) for the guesser. Then, the game switches the roles of the players by changing the screen orientation for the player who will be playing as the mime and the next round of GuessMe starts.

As shown, the players will be validating one another. This design decision (over multiple-choice question) helps to build rapport between the players and increase play initiations (IPG model practice 1). The script for each button are as follows:

H9: *He is correct.*
Script for step 6, Green button: ***Well done, now it is Yellow's turn to guess.* ***(**only in tutorial)***
H10: *He is incorrect.*
Script for step 6, Red button: *That's alright, try again.*

Overall, the game has supported scaffolding play (IPG model practice 2) by offering support without hindering the natural flow of play via:

- The help buttons which gives optional and repeatable explanation for the game buttons. This allows the players to learn what each game object does at their own pace.
- Although players may skip their hints or have incorrect attempts, they can always try again. This allows the players to make mistakes until they get better. The Zone of Proximal Development (ZPD) is guided by letting each level of player play at their own pace (IPG model practice 4). This is because novice players might perform actions and roles that they may not yet fully understand while mutually engaged in intrinsically motivating activities and themes (Wolfberg, et al., 2012).

4.3.3 Revised Game Design

4.3.3.1 Card Game Design

FIGURE 44. CARD DESIGN FOR TYPES OF HINTS

As shown in Figure 44, cards design was decided over buttons because they are representations of something tangible and hence, can be 'given' to the other person. This creates an illusion of shared resources between players and thus, increases cooperation [A1] (El-Nasr, et al., 2010). When each card is pressed, a flipping sound is made to imitate the action of picking up a card.

Moreover, similar to old-school collectible card games, each type of hint card is more 'powerful' than the other based on the number of sushi on them. More sushi are on the card which encourages the mime to act out or give sound hints to show the child with ASC or let the child with ASC practice pretence [A1] (IPG model practice 4). For guessing right, the guesser gets one sushi.

4.3.3.2 Main Game Interface

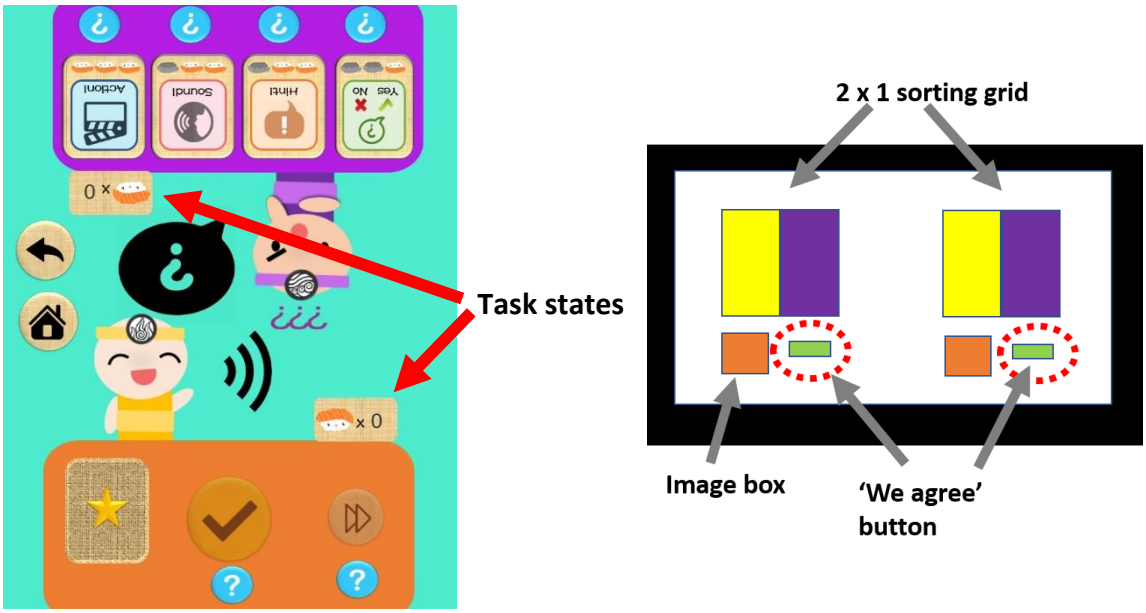

FIGURE 45. SCOSS DESIGN COMPARISONS (HOLT & YUILL, 2014)

As shown in Figure 45, the main game interface keeps the players' buttons separated by marking their spaces on the screen with 'tables'. This was structured according to the SCoSS interface design to make it explicit that the users should be controlling their own task space. Moreover, both users have the same task (collect sushi to feed Poopzilla), with

representations of both their own task states and their partner's on the same screen. By having SCoSS design features, collaboration and shared understanding between the players are supported, increasing other awareness in children with ASC when paired with a TD peer (Holt & Yuill, 2014).

4.3.3.3 Augmentations

Augmentations were made based on entities the children have created from the design workshop in Chapter 3. This is to ensure that the themes of the game objects are tailored around things that get children excited [B1].

TABLE E. AR IDENTITIES LIST THROUGHOUT THE GAME

Round no.	Yellow's identity	Purple's identity
Tutorial	Cat	Monkey
1	Pirate	Clown
2	Magician	Mermaid
3	Dog	Unicorn
4	Ninja	Santa
5	Dragon	Astronaut
6	Viking	Elephant

FIGURE 46. AUGMENTATIONS CREATED FOR GUESSME ROUNDS

4.3.4 Revised Game Tutorial

The tutorial screen sequence was revised to explain the game goal of each round of GuessMe (Figure 47, B). The script for the tutorial sequence is as follows:

Screen A: *The goal of the game is to earn as many sushi as you can together. Press your button to proceed. Your button has the colour of your agent's name.*

Screen B: *During each turn, one of you will have to guess your secret identity. It may be an animal, a type of person or a magical creature.*

Screen C: *Now sit across each other. Both players will be taking turns during the game. One player will be guessing who he is. To demonstrate, *face change* agent purple will be the guesser.*

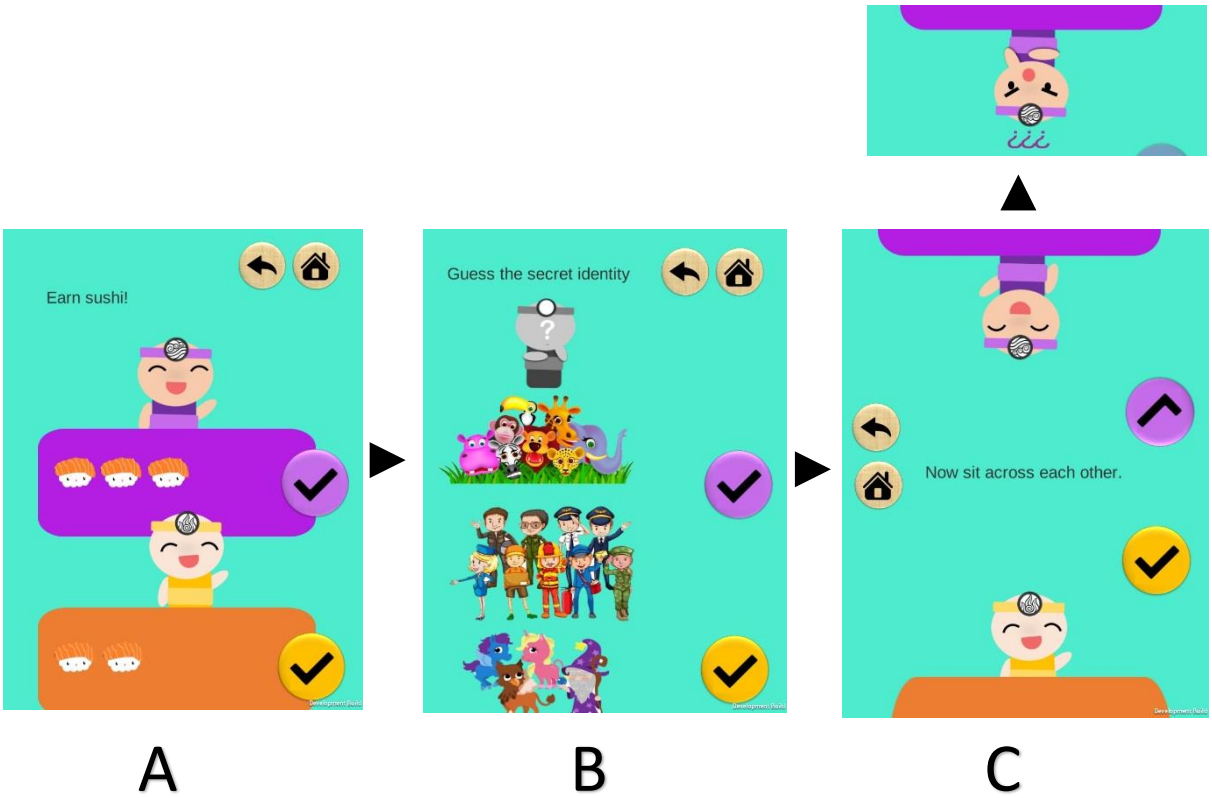

FIGURE 47. REVISED TUTORIAL SCREENS

4.3.5 Free Play Mode

As a fun add-on, a free play mode, shown in Figure 48, was made for children to bond over, explore and try on different random augmentations with their peer. However, due to an update bug with Vuforia, the mode was unable to run using the front camera (the rest of the game AR scenes would be using the tablet's front camera) so that both children can see their augmented faces together. Thus, the additional feature does not include planned photo taking capability.

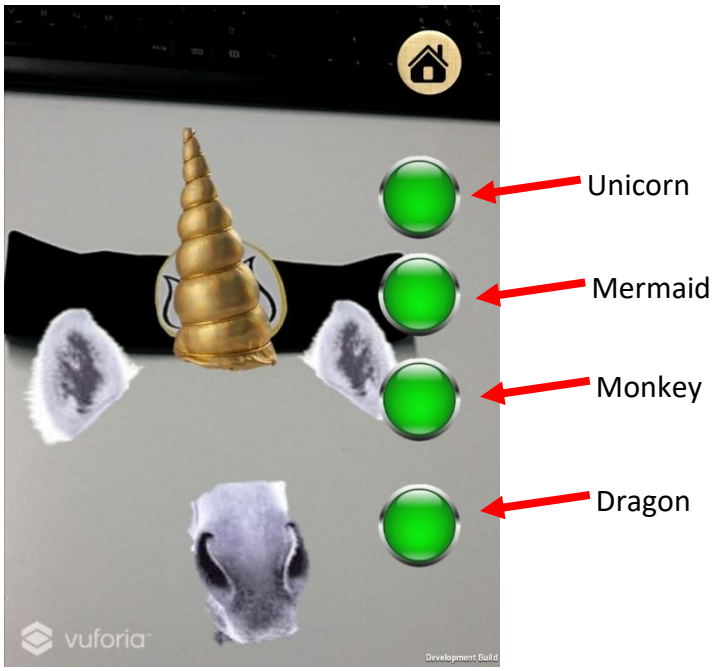

FIGURE 48. 'PHOTO-TAKING' FEATURE ADD-ON PROTOTYPE

Chapter 5

Game Evaluation

This section contains the evaluation of the high-fidelity prototypes with TD children and experts from academic sector. The two studies were conducted with 18 children in total.

5.1 Evaluation with Children

5.1.1 Aim

The aim of the testing session was to:

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

5.1.2 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 assured 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.

5.1.3 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 assured 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, split into 2 teams (Yellow Vs Purple) and guided to the game's introduction sequence. With groups of two, the children alternated wearing the headband per round. After that, they were free to play the main game with little interference from the tester. Their reactions were observed. After 15 minutes, the children were asked to fill in a child survey made to test their response towards the app (see Appendix E). The survey asked for one thing they liked and disliked about the game, whether the game was fun to use and the Fun Toolkit (shown below), which is a method to gather opinions in child computer interaction (Read & MacFarlane, 2006). Due to time limit, only one group (Group 1) played the free play mode because they were able to finish the main game faster. Groups which completed 'Half-session' did not do the survey nor complete the main game (4 rounds out of 12 rounds).

FIGURE 49. FUN TOOLKIT QUESTION IN SURVEY

5.1.4 First Evaluation Session

5.1.4.1 Participants

The test was conducted over 2 full sessions with 4 girls (1st Group) and then another group of 4 girls (2nd Group) aged 8 to 9 (no siblings) in a games hall. The 3rd group of participants did half a session due to time limit. All participants' literacy levels were sufficient to understand instructions and express themselves.

TABLE F. EVALUATION WORKSHOP CHILDREN INFORMATION

Workshop Children			
Child	Sex	Age	Siblings
1st Group			
S1	Female	9	
S2	Female	9	
S3	Female	9	
S4	Female	8	
2nd Group			
S5	Female	9	
S6	Female	7	
S7	Female	7	
3rd Group (half session)			
S9	Female	9	
S10	Female	9	
S11	Female	8	

5.1.4.2 Results

A. 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. 4 children voted for 'Really good' while 3 voted for 'Brilliant'.

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 that would cause the children to not enjoy the game.

Question: One thing you liked about the game?

Other than 'Everything', the children's written answers were:

- *Get to act out*
- *Being able to get lots of hints*
- *The mask filters*
- *Funny*

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

Other than 'Nothing', the children's written answers were:

- *Longer (wanted more rounds in game)*
- *Embarrassing*
  Two children wanted to be able to see what they looked like augmented because their peers were laughing behind the tablet.
- *Wish more people can play*

Having more players per team in the game does not apply as the game is meant to be played by two players. However, from the observation discussed below, it was noted that 2 versus 2 players dynamic resulted in more cooperative behaviours between players. This game design option will be discussed with the experts in the next section as the reactions may be different for children with ASC (5.2).

B. Gameplay Comprehension

The children were able to pick up the game at a fast pace and gameplay dynamic between the teams was smooth. This may be due to their familiarity with card games and charades or the game design being intuitive. However, none of the children pressed the 'Help' buttons for any of the game elements even though there were a few aspects of the game they were unsure about. Some children chose to directly clarify uncertainties with the tester instead. These aspects were:

- The hint button for the entity during the AR scene. One child was unsure of the entity, she assumed she was right and click the OK button even though she made a wrong guess. It had to be pointed out to the children that there is a 'Help' button to confirm the entity of the augmentation they are viewing.
- The skip button was untouched by most children. Some were oblivious to its existence, one girl commented "There's a skip button?" when asked to use it. This may be because the skip button was coloured neutrally and hence, was not noticeable enough.
- Misunderstanding of OK button after giving hint. All children pressed the OK button immediately regardless of whether they gave hints or not. This awards sushi to player even if they did not give the type of hint required. However, game flow was not interrupted because of this.
- The yes-or-no question hint had to be clarified to a girl who deduced "I'm the guesser so I ask the question right?". The rest of the children knew what to do. The children were free to ask as many yes-or-no questions as they liked.

C. User Behaviour

Overall, the children were laughing and seemed to be having fun playing the game. One child commented "It's the kind of game I was looking for". As social support is also being evaluated, it

is important to note that these groups of children meet up weekly to do group activities. Hence, the interactions observed may not be accurate for players who are complete strangers.

A lot of guessers chose the act out hint (most popular type of hint) and none of the mimes chose to skip acting out. For example, children were acting out cutting a person in half or pulling a rabbit from a hat for "magician", laying on a rock wiggling both their legs as tails and tossing their hair for "mermaid", slow-motion walking with elevated arms for "astronaut" and pretending to scale a wall while throwing weapons for "ninja". This is a huge improvement over the charades session held in the design workshop (Chapter 3) where the children were reluctant to act out at all. Moreover, it is interesting to see that having 2 players on a team led to a faster game pace and enjoyment as the players within the team discussed (whispering to each other's ears) and helped each other out when one player (mime) is stuck or taking a longer time to come up with the hint.

The mimes were naturally validating the guessers. No team were giving the other team the solution/entity word right away. Hence, the game's validating mechanism is effective based on the session's observation.

To close the entity photo and text tag shown from the 'Help' button, the game initially expected the children to tap on the photo as shown in Figure 50. However, all children tried tapping on the 'Help' button again to close the hints. Thus, the 'Help' button was updated to close the hints instead (shown in red in Figure 50).

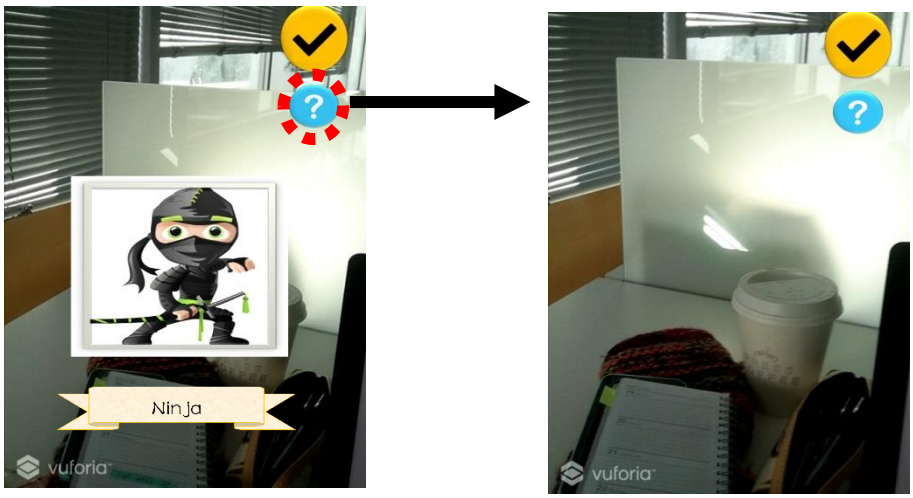

FIGURE 50. CHANGED BUTTON INTERACTION IN RED TO CLOSE THE HINTS

There was a lot of laughter and communication between the mime team and the guesser team. The children have found their peers being augmented hilarious. This caused curiosity from the guesser (one child asked "What's so funny?") who sometimes tried to look over into the screen being held by the mime to find out who they are. This helps gives the guessers incentive to guess who they are and become more engaged in the game. However, as shown by the survey, a few children found it embarrassing to be laughed at. Hence, the game design was updated (below) to allow photo taking during the AR scene so that the guessers can see how they looked like earlier on.

The children were also entertained by the button's farting noises and game introduction story. At one instance, two teams were ready to compete with one another after wearing the headbands (one child challenging the other). However, the story of the agents being best

friends drew “Aww” reactions from the players and the competitive atmosphere became lighter.

It was also interesting to observe that the children were excited to wear the headband. Even though it does not matter which child in a team wears the marker, every child wanted to wear the headband so they had to take turns within the team. It might be because having something tangible to play as characters in the game helps them become more engaged in the game. Also, it meant that the children liked the headband markers.

5.1.4.3 Game Update

Some design changes were made to tackle some issues from the evaluation workshop. The first set of changes was the game’s ‘Help’ buttons. In the AR screen as shown in Figure 51 (left), the icon for the ‘Help’ button was changed from a question mark to a lightbulb (another generic icon for hint) which may be more eye catching for the children. Also, all ‘Help’ buttons’ colours were changed according to the agent’s colour (Figure 51). This design change was made based on the assumption that the children would only be interested in using ‘their’ buttons which are coloured according to their character’s name during the game. These changes will be tested with another evaluation workshop to see if making the ‘Help’ buttons more noticeable help increase their usage.

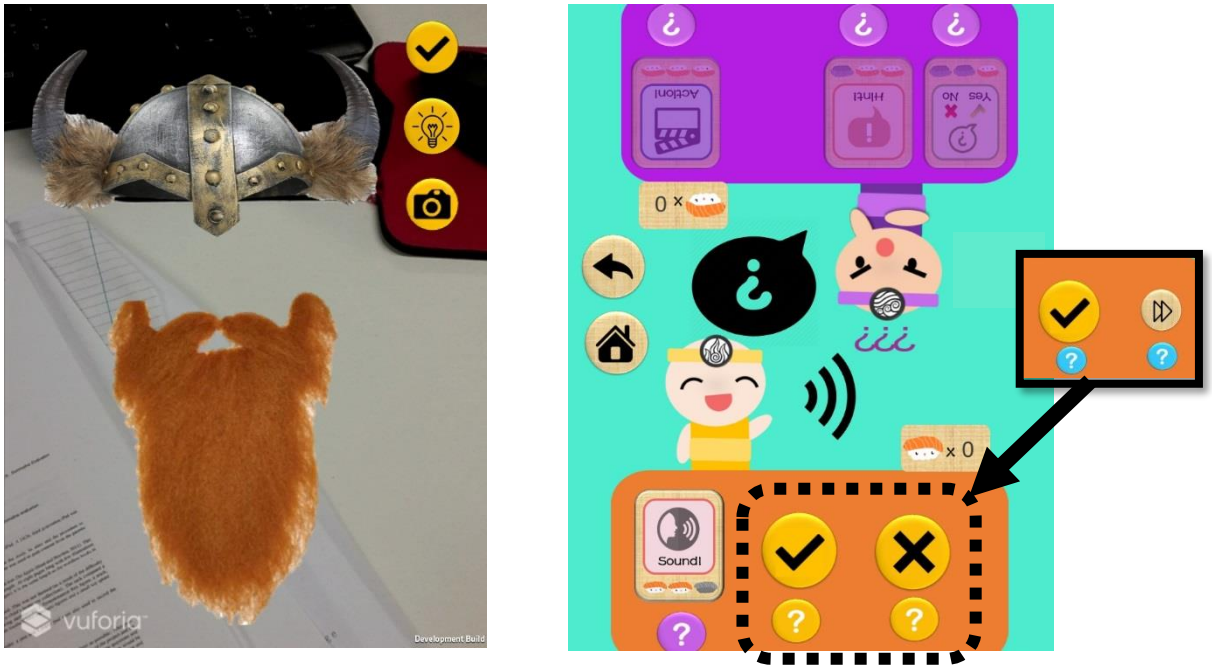

FIGURE 51. UPDATED DESIGN. LEFT: HELP BUTTON AND CAMERA OPTION. RIGHT: HELP AND SKIP BUTTONS.

The second set of changes was the Skip button for the mime player as shown in Figure 51 (left). Again, the button was made more noticeable by having it bigger and with the same theme as the OK button (tick and cross). This is to convey the message that both buttons are responses to the same question of whether or not the mime would want to give the hint. Again, this feature will be tested in the next evaluation workshop to see if more children will use the Skip function when they need it.

The last change is the photo-taking feature in response to the children wanting to be able to see themselves augmented. The mime will be able to take a photo of the augmented guesser using the camera button shown in Figure 51, left. Then, after the round for that entity is done (in this example, "viking"), the photo is shown to the guesser before the game moves on to the next round Figure 52.

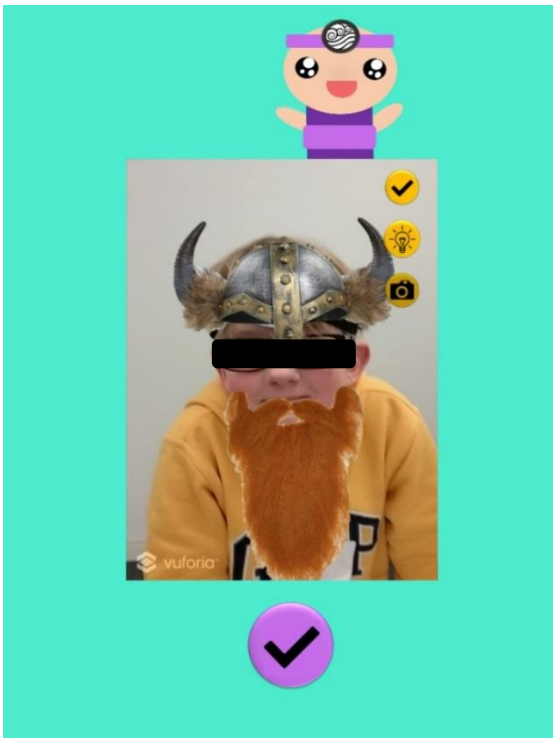

FIGURE 52. A CHILD'S PHOTO REVEAL FROM LATER EVALUATION WORKSHOP

5.1.5 Second Evaluation Session

This evaluation session also tests for any improvement in response to changes made to the game design.

5.1.5.1 Participants

TABLE G. EVALUATION WORKSHOP CHILDREN INFORMATION

Workshop Children			
Child	Sex	Age	Siblings
1st Group			
S1	Female	6	Yes
S2	Female	8	
2nd Group			
S5	Male	9	
S6	Female	12	
3rd Group			
S9	Male	8	
S10	Male	12	
4th Group (Half session)			
S11	Male	12	

5.1.5.2 Results

A. 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. 3 children voted for 'Really good' while 3 voted for 'Brilliant'.

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 that would cause the children to not enjoy the game.

Question: One thing you liked about the game?

Other than 'Everything', the children's written answers were:

- *The questions (yes-or-no questions)*
- *Fun*
- *The aim of the game (to gather sushi) and how it uses filters*
- *The pictures (the child had fun posing for photos)*
- *The variety of different things to describe*
- *Gameplay*

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

Other than 'Nothing', the children's written answers were:

- *Too long*
  Also, the headband seemed uncomfortable for the child as she kept taking it off. When asked, she nodded that it was uncomfortable for her.
- *Guessing answers*
  The youngest child, 6 year old, found some identities (i.e. ninja) too difficult for her to guess. However, she seemed delighted when she got the simpler identities (i.e. dog) correct.
- *Make it more difficult to cheat by saying the answer of the game.*
  One of the oldest children, 12 year old, pointed out that confirming the identity answer at the end of each round would improve the game validation mechanics. Currently, the photos are shown at the end of the round only if they were taken.
- *Too loud (game menu music volume was too loud for the child)*
  The menu music volume was lowered after the workshop.
- *No background music (during the main game)*

B. Gameplay Comprehension

A few children used the 'Help' button in the AR screen and the 'Help' buttons in the shared screen (i.e. in Figure 53). Thus, the audio was edited and updated to "Hold the device up to see purple's secret identity. If you are unsure, click on the help button.". Also, not all children who wanted clarification on game elements pressed the 'Help' button. This may be because the tester was present and thus, the preferred way for the children to get help is to ask. Encouraging the children to use the 'Help' buttons will be discussed with the experts in the next section.

The new tick and cross design in Figure 51 (left) was misunderstood by a child as meaning “yes” or “no” for the yes-or-no question hint type. Another child interpreted the tick as meaning “Ok I know what type of hint I’ll have to do”. Thus, the redesign ineffective.

Moreover, the children still did not seem to grasp that the cross is a skip button. The buttons were once again redesigned to ensure better functionality comprehension. As shown from Figure 53, additional text was added to make it clearer to the player what the buttons meant. The icons were replaced to neither resemble yes or no icons. The Skip button icon resembles the Skip icon in the popular Uno card game.

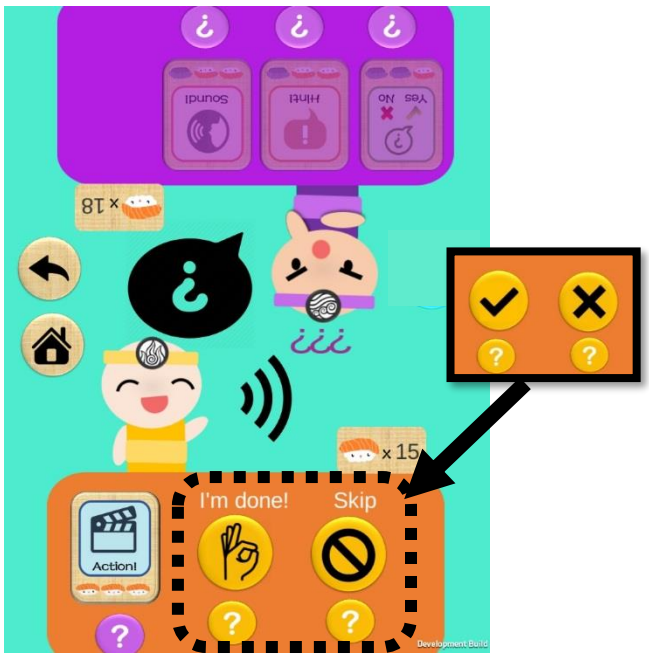

FIGURE 53. REDESIGNED BUTTONS.

Lastly, a pair of children were able to skip parts of the tutorial by pressing the consensual buttons together. Thus, the tutorial was updated so that both the buttons were kept uninteractable while the tutorial audio is playing.

C. User Behaviour

The pace of the game, which is important to keep children engaged, was slower as compared to 2-versus-2 players’ game dynamic. However, overall, the children seemed to enjoy the game. Some children were laughing throughout the game. One child commented ““this would be a good game to play with my sister””. Another child remarked that the game was ‘cool’. When asked, all the children liked the photo taking feature. Again, the type of hints that were most frequently chosen by the children were action and sound hints. However, not all mime players acted out. An older boy (12 year-old), instead, chose to describe how the entity is likely to act.

For one of the rounds, the youngest child of the group was unable to guess after all the types of hints were exhausted. The game dynamic was slowed down and the round seemed too drawn out for her. At the end, the other player had to tell her the answer. This implies that some of the game’s entities (i.e. ninja) may be too difficult for children her age (6 year-old). Thus, care has to be taken to adjust the difficulty of entities according to the player’s ages. Also, a way to let the guesser skip the round altogether or support to help struggling players might be helpful.

It was also noted that for some entities, it was difficult to give sound hints. For example, the children did not give sound hints for ‘astronaut’. Instead, some improvised and acted out while others skipped. One way to solve this is to replace sound hints with other types of hints for silent entities. This redesign possibility will be discussed with the experts later on.

5.1.6 Summary

In conclusion, the game generally has good level of 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. photo taking, children-themed entities, humour and types of hints). However, some requests made by the TD children such as having background music during the main game may be distracting for children with ASC as they are susceptible to sensory overload.

There is also good level of usability. Even though there was a button that was being missed out (the Skip button), the users were able to play the game smoothly regardless. The issue, however, will have to be fixed and this will be discussed later on with the experts to evaluate the redesign decisions. Moreover, it is to be noted that the set of entities in the game will have to be tailored slightly or a game round should be skip-able altogether to make it easier for younger children.

Comparing the two evaluation workshops, children who were already familiar with one another and played the game as 2-versus-2 players (first workshop) completed the game much faster, were laughing together more and were less hesitant to give hints. However, having more players in the game may not be ideal for children with ASC, although having a familiar peer such as his/her TD sibling or friend may help improve game dynamic. This observation will be discussed in the next section with the experts.

It was shown that the game was effective in encouraging the TD children to act out in front of their peers. However, there were a few instances where a TD child was still too shy to act out. This may be, again, because of the tester's presence or the child's personality. As shown in the IPG studies, the TD peers were selected based on demonstrated competent social, communication, and play abilities and express an interest and willingness to participate (Wolfberg, et al., 2012). The game will not be able to effectively support social play between the children if the TD peer chooses to not to play along. Hence, willing TD peers may have to be specifically chosen to support children with ASC for the game.

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 8, two of the same experts who participated in the low-fidelity prototype interviews also participated in this evaluation session.

TABLE 8. LIST OF EXPERTS IN EVALUATION OF HIGH-FIDELITY PROTOTYPE

Expert	Background
E1	Research associate professor with main research interests in Human-Computer Interaction, digital learning, multimodal Interaction, assistive technologies, educational technology and technology for autism.
E2	Research postgraduate student researching in multi-player game applications for young children.
E3	Adaptive learning environment professor who specialises in developing learning environments for typically developing children and children with ASC.
E4	E-learning professor who has a grandchild with ASC. He specialises in learning technology and human response to technology with interest in educational technology for children
E5	HCI professor who specialises in human factors of security and privacy system

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 headband markers. For E3, a headphone was provided (to listen to the game audio 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 tutorial and then the main game. After that, their feedback on the game was 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. If time permit, further improvements were also requested based on the children game evaluation sessions.

5.3.5 Results

5.3.5.1 Game Effectiveness

E1, E2 and E4 agreed that the game is good for supporting social interaction and pretend play for children with ASC. The game is good for pretend play because it gets the children to act out different roles while allowing for visual support of pretence by seeing their peers augmented. The experts found the game engaging and fun for TD children and children with ASC. E2 liked the sushi score incrementing the more the player gets into the role. This may be why the children in the evaluation workshop preferred action and sound hints. E5 and E3 liked the split workspace interface for the two players.

E2 mentioned that the game's premise was set well with the story. E4 adds that a game story ending would be good to wrap up the game. Moreover, she suggested showing the Poopzilla eating the sushi earned per round.

E3, E4 and E5 liked the physical turn taking aspect of the game whereby there is flow while the players are handling the tablet (one kid picking it up, then puts it down before the other kid picks it up etc.). The players will not have to re-orientate the tablet between turns because the screen is already orientated to suit each player sitting across each other. E5 commented that the tablet turn taking design makes sense while E4 mentioned that the game has emphasised turn taking for children with ASC well.

In regard to the option of having 2-versus-2 player mode, E4 advised against it because he believes that having more players draws the focus and support away from the child with ASC. Hence, it is "not the dynamic a child with ASC might want". E2 on the other hand supports the option because it supports communication within each team and between the teams. Thus, cooperation and collaboration is emphasised.

Both E3 and E5 agreed that the free play add-on mode in the game can be fun for the children.

5.3.5.2 Overall Usability

E2, E3 and E4 had no issues with the game's interface usability for TD children and children with ASC. However, to improve usability, the observations made during the children evaluation workshop were discussed to get further suggestions for the game's final redesign.

E1 suggested that the red and green buttons for game validation stage on both the players' panels look different because "they perform different functions". However, they represent 'yes' or 'no' answers to the game's question i.e. "Can Purple guess his secret identity?" or "Yellow, was Purple correct?". Thus, the buttons do perform the same function if the user listened to the game audio. In cases where they do not pay attention, E2, E4 and E5 suggested

having textual aide above the buttons such as “Are you ready to take a guess now?”. E5 also suggested letting instructional audio be repeatable.

In regard to types of hints cards, the following comments were made:

- E2 recommended not removing the sound hint for silent entities as it does not halt progress within the game. Moreover, it allows for consistency throughout the game.
- E4 finds the yes-or-no hint difficult and warned that it may be challenging for young children to come with good yes-or-no questions which eliminate the set of possible guesses. However, E1 thinks that the hint will be fun for the children. Based on the workshops with TD children, most of the children were fine with the hint type as long as the number of questions required to be asked were less than 4.
- E5 suggest making it explicit how many yes-or-no questions should be asked as children with ASC might be uncomfortable with the uncertainty of rule for the hint type.
- E5 also advised editing the “Help” button script for the yes-or-no question to make it directed at each player so that it is more obvious which child is supposed to be asking the question.
- When all hint cards are exhausted, E1 and E3 agreed that ending the round with the AR photo taken beforehand can help struggling players. Thus, photo taking in the AR screen has to be mandatory (currently optional). On the other hand, E2 recommended letting the mime draw a sketch of the entity as a hint as well.
- Lastly, E5 commented that the sound and yes-or-no hint cards are red and green which can make the user associate them with something bad or good. Hence, she advised changing them into neutral colours to avoid cognitive bias.

For the AR screen, E5 advised showing the confirmation of identity as a name tag augmented on the guesser’s chest. This suggestion was based on her research on user attentional bias whereby it was shown that when focused on a task in a noisy environment (webpage full of information), users usually miss out on the most salient helpful (for their assigned task) information as their brain would categorise it as junk adverts. This explains why few children pressed on the AR screen’s ‘Help’ button (which was redesigned to be more salient) as they were focused on processing what they are seeing. Making the identity confirmation part of the AR helps to integrate the information into the children’s attentional field. E5’s usability insight also explains the low frequency of usage for all the ‘Help’ buttons throughout the game.

Lastly, additional suggestions for usability improvement was made below:

- For children who might be uncomfortable wearing the headband, E3 suggested having a handheld design for the AR markers. Moreover, she also suggested having a mute button for the music playing in the menu as some children with ASC might find it annoying.
- E5 advised having the main game start with a screen instructing the players to sit across each other according to their chosen agent colour (like in the tutorial). This is so that returning players can re-orientate themselves without having to go through the tutorial again.
- E3 noticed that the audio instructions overlap when another button is pressed while an instruction is already being played.

5.3.5.3 Game Tutorial

Both E1 and E5 had difficulty understanding the majority of the game during the tutorial while the rest of the experts and TD children from the evaluation workshops were able to understand the overall gameplay from it. This may be because familiarity with charades or card games helps with the game's comprehension. E1 pointed out that the game should not rely on generalised game knowledge and should be suited for players of all levels of familiarity with similar games. Thus, she suggested having more detailed tutorial or have the child's caretaker (etc.) present to clarify anything the child may be unclear about accordingly. Additionally, E1 suggested changing all 'Help' buttons back to the same colour so that they are consistent.

E2 suggested breaking down the steps in the game and going through these steps in the tutorial. Once it is done, a rules book can be made accessible during the game so that the players are reminded of the game rules.

5.3.5.4 Further Improvements

As a fun add-on for the game, E2 suggested having the free play mode as a creative space for children to draw their own masks so that they themselves can create their own entities. This way the game will not run out of 'rounds' as the children are in charge of creating them. Moreover, this also reinforces pretend play skills as the children creating new identities for pretence. E4 agreed that this idea would be fun for both TD children and children with ASC. Unfortunately, due to time constraint, this great suggestion cannot be implemented but will be added to future work.

5.1.4.5 Game Design Update

Additional improvements to the game were made based on experts' suggestions. These changes are covered below. Some changes, however, were not implemented due to time constraints or redundancy to other changes:

- Rules 'book' to remind players of game rules.
- Add-on feature to let children design their own masks.
- Fixing audio overlapping which happens when player's pace is faster than that of the game (although unlikely to be the case for children with ASC).
- Fifth type of hint which allows mime to draw out his/her hint.
- Handheld AR marker design.
- Name tag augmentation. The redesigned tutorial (below) has increased emphasis on the use of 'Help' buttons. The game will not be relying on by-chance approach that the user will notice the buttons, thus, the augmentation feature suggested may no longer be necessary.
- Letting instructional audio repeat. Textual direction (below) and repeatable instructions from 'Help' buttons will instead be supporting the absence of this feature.

A. Game Menu and Tutorial

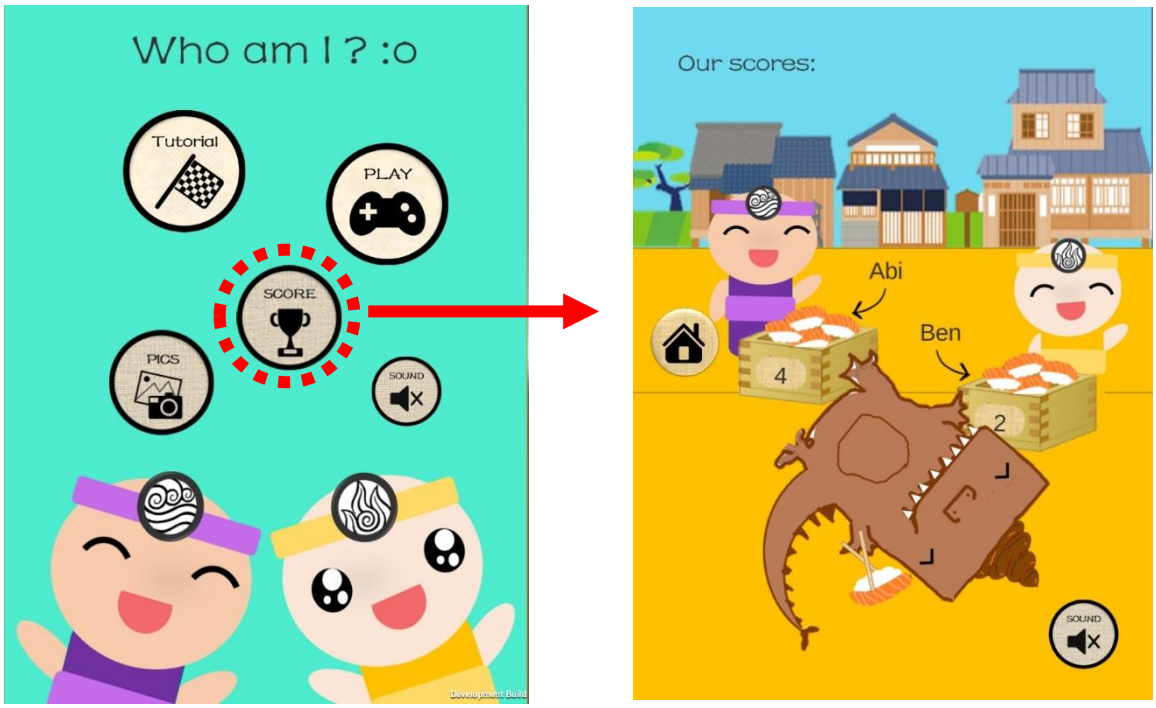

FIGURE 54. REDESIGNED MENU (LEFT) AND SCORE SCREEN (RIGHT)

- As shown in Figure 54, mute buttons have been added to the game menu and score screen to mute the background music.
- A conclusive story scene has been added as the scoreboard screen which will also pop up at the end of the main game rounds. It consists of the Poopzilla spinning happily with his new friends in the background (Figure 54, right).

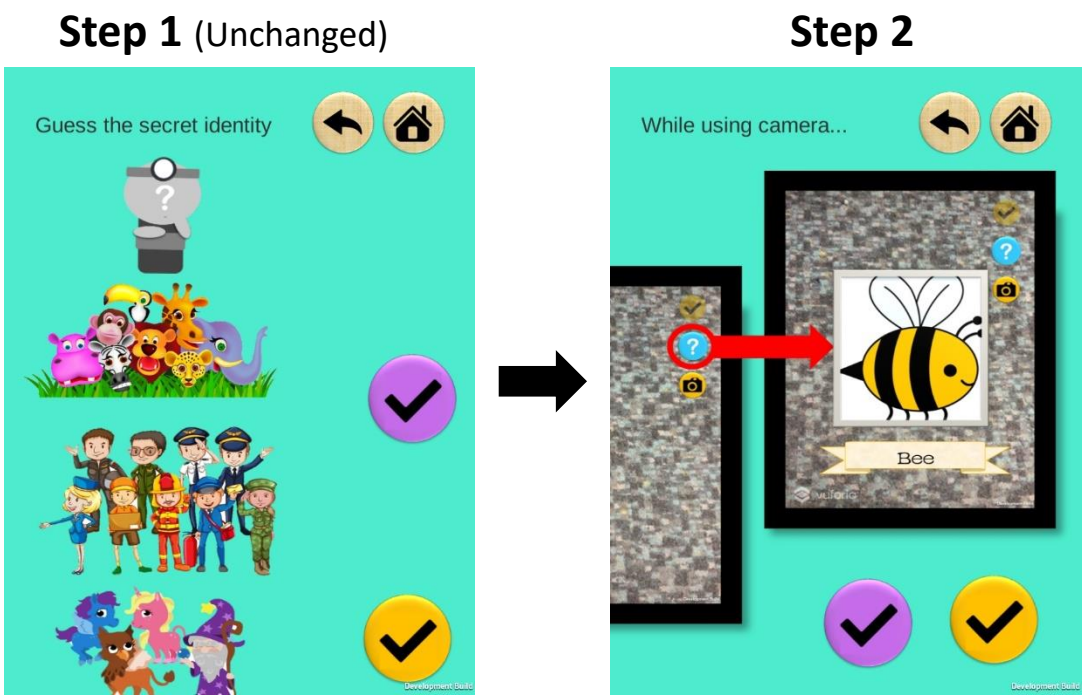

FIGURE 55. REVISED TUTORIAL: STEP 1 AND STEP 2

- Tutorial is more detailed by putting emphasis on the players utilising the help buttons during the AR screen (Figure 55, right). The script for Step 2 is: "*While using the camera, press the blue button to get help.*"
- The game's sound and yes-or-no hint cards were recoloured as per E5's advice (Figure 56, top).
- All 'Help' buttons have been changed back to blue colour to imply same functionality.
- Each type of hints is explained through pressing of the 'Help' buttons for both players. The tutorial screen is not skippable until all the 'Help' buttons have been pressed (Figure 56, top: left to right). This also encourages the use of the 'Help' buttons below game objects to alleviate usage uncertainties.
- The yes-or-no card has been redesigned to make it more explicit that only 3 questions are allowed per turn (Figure 56, top). The updated 'Help' button audio for the card is: *"The guesser asks 3 yes or no questions."*. This also makes explicit which player should be asking the questions.

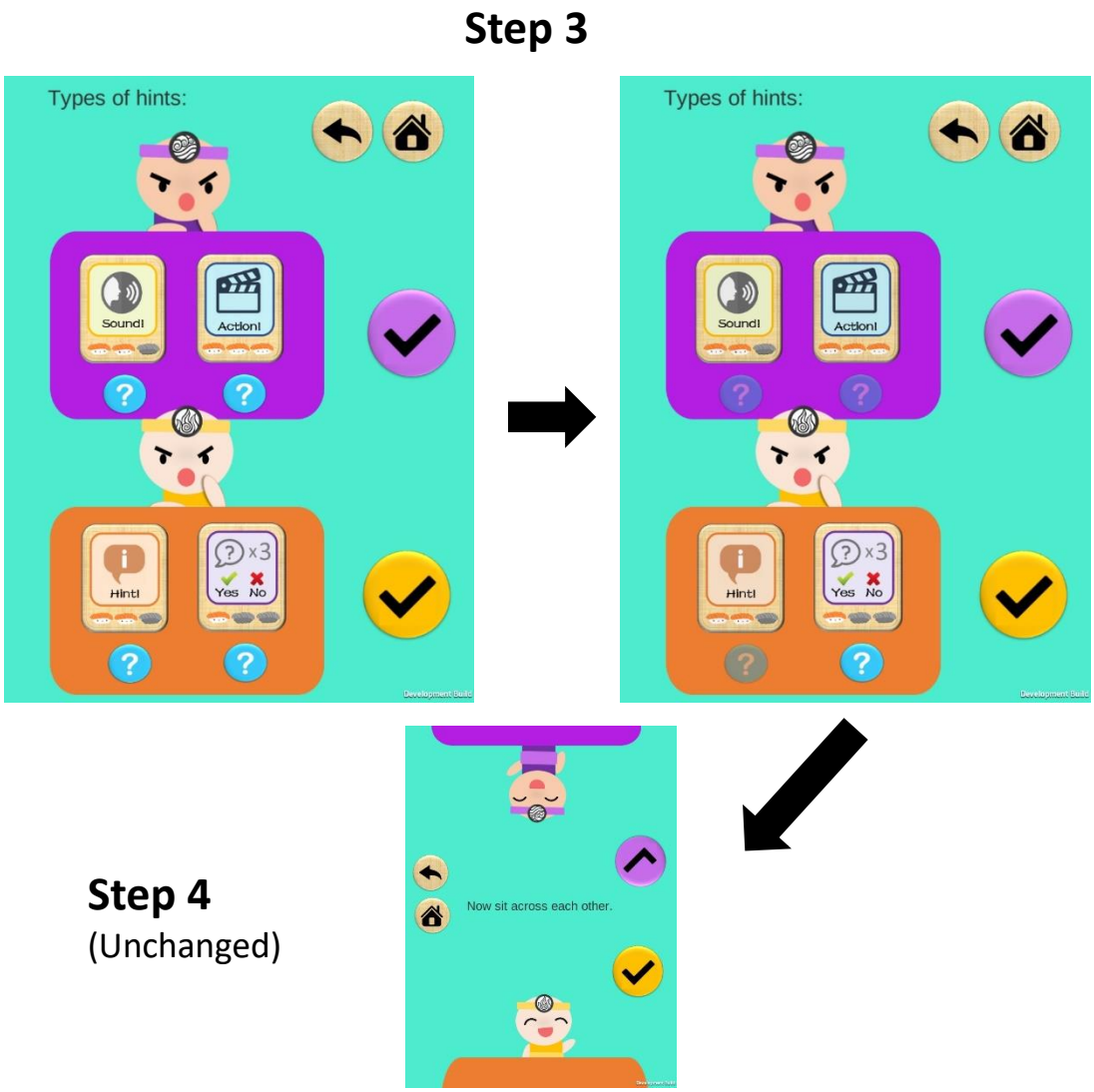

FIGURE 56. REVISED TUTORIAL: STEP 3 AND STEP 4

B. Main Game

- The player orientating screen in the tutorial (Step 4 in Figure 56, bottom) is shown at the beginning of the main game.
- Textual cues are given above buttons i.e *"Do you want to give hint?", "Do you know your identity?"* and *"Was he correct?"* in Figure 57.
- The OK and Skip buttons were redesigned into cards so that users will pause to consider between the two options given. The children in the workshop had reflexes to press the OK button right after they understood what hint they had to do. Thus, having card designs might increase the chance of them thinking about which card to 'use'. Additional text on the cards also tell the user what each card does i.e. "Do hint".

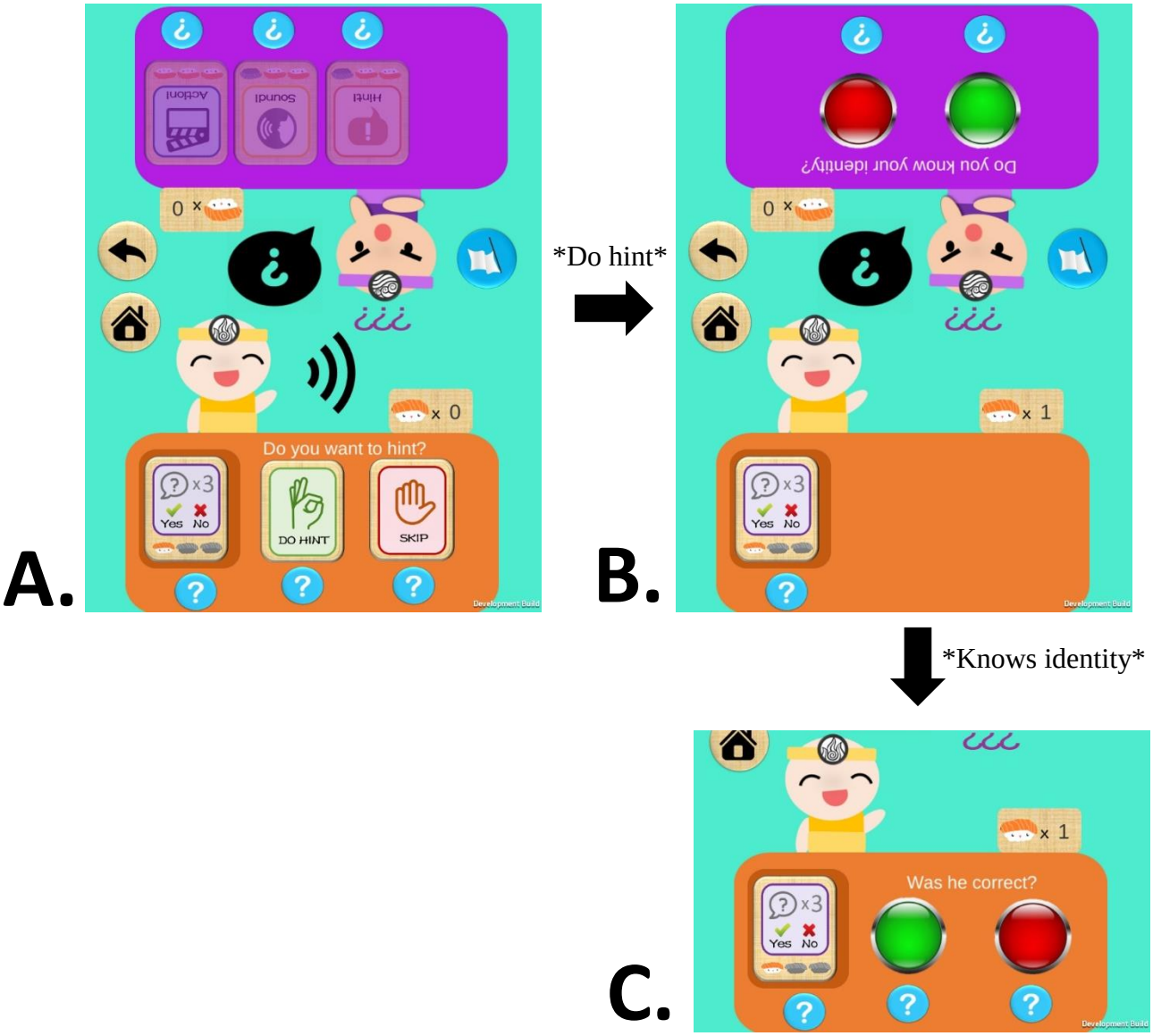

FIGURE 57. REVISED GAME DESIGN

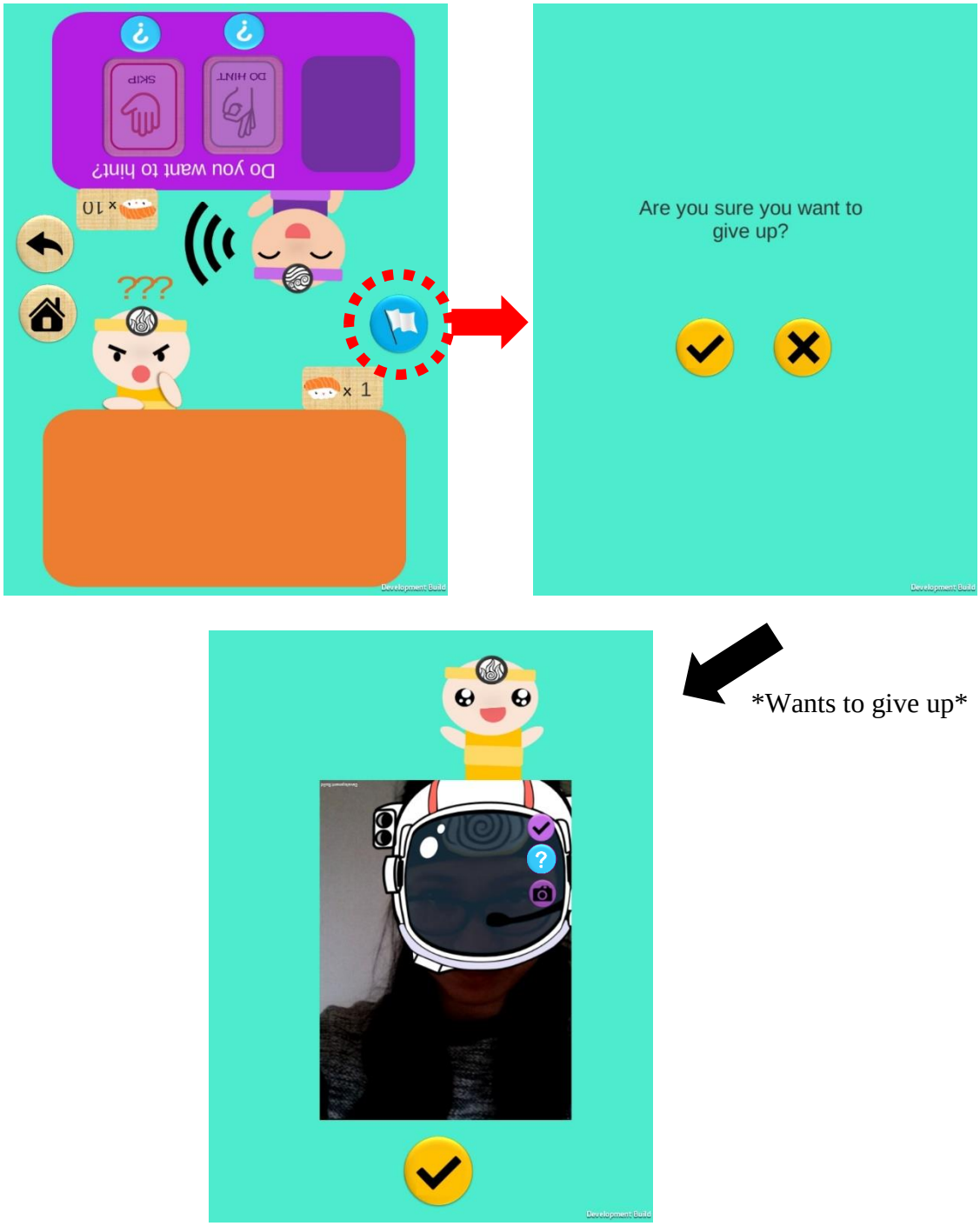

FIGURE 58. SKIPPABLE ROUND FEATURE

- A feature to skip the round is given for guessers who are struggling. The button encircled in red shown in Figure 58 leads to a screen where the player can confirm whether he/she wants to give up. This is so that the players will not be skipping rounds accidentally (user safety). No 'Help' button is needed for the feature as it double checks the user's action. The photo taken (now compulsory) by the mime earlier is shown to the guesser who gave up as identity reveal (Figure 58, bottom).

5.3.6 Conclusion

The experts were positive about the potential effects of the application on children with ASC. They felt that the social interaction for the children within the game was supported via emphasis on turn taking, game story and game goals (different number of sushi reward per hint card). Most of the experts also found the game fun for young children.

Furthermore, from experts who were unfamiliar with card or charades games, insights have been made for unexperienced players. Thus, more support such as textual cues and emphasis on utilising the help features within the game has been implemented. The experts generally liked the game interface (i.e. split work spaces) and suggested improvements based on the children evaluation workshop results. Most of the suggestions have been worked on in the game's redesign and thus, the game's usability has been improved.

Overall, the evaluation 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 are 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 3.1 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 two-player AR game tablet app to encourage peer support for 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 3.1. 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 can a game be designed to encourage pretend play for children with ASC?'*, 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 main 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 and TD children?

Game Interface and AR Feature

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 details that were overlooked were fixed (i.e. button press to close hint in AR screen or lowering volume of music in the menu).

There were, however, issues with the players misunderstanding the OK button after the mime player was given a hint card and 'Help'/ Skip buttons not being used by the children during the game. These issues were fixed via consulting the experts during the expert evaluation sessions and redesigning the game interface elements according to their suggestions and insights.

The children were able to easily use the AR screen as the app could consistently track the big markers on the users even in low light settings, thus, there were no issues with the game's AR usability. The experts found that the adaptive screen orientation for each player sitting across each other made the game easily usable and sharable for young TD children and children with ASC.

Game Comprehension

From observation, all of the TD children were able to easily pick up the game and play through it with their peers smoothly. Thus, the language used, visual support and sound effects were appropriate to help the children comprehend the game states and support turn taking. Two experts, however, had difficulty understanding the gameplay. The game tutorial was thus, altered to ensure more support for inexperienced players (little experience in card/charades game).

Overall, the experts agreed that children with ASC will most likely know what is going on within the game if the game's tutorial is more detailed. Thus, redesigns on the tutorial have been made according to their suggestions to step the players through the game. Moreover, throughout the rounds, the game allows for predictability and consistency which some children with ASC may enjoy.

Verdict

Given the evaluation results and improvements made, the AR game will most likely be appropriate for TD children. However, depending on player's experience with games in general, the game may be appropriate for children with ASC. An adult may need to be present at the beginning of the game to further guide the child should he/she need help understanding the game. More studies will need to be carried out to evaluate the latest game tutorial redesign.

6.1.2 Satisfaction

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

The experts were positive that children with ASC and their TD peers will enjoy the game. Based on the surveys, the TD children gave the game positive ratings because they liked the game's varieties of hint types (choices), gameplay, augmented masks, photo taking feature, humour and goal. There was a lot of laughter from the TD children during the workshops, especially when viewing their peers with mask augmentations.

Verdict

Given the evaluation results, the target groups 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 good for teaching children with ASC how to pretend play by encouraging them to act out via peer support and AR visual support. They also found that the game has good emphasis on turn taking for children with ASC. Also, the game encourages acting out for TD children. There was a vast difference in the number of TD children willing to act out in front of their peers during the design and evaluation workshops. By ensuring that the TD peer will be willing to model pretend play behaviours (acting out) for the child with ASC, the game is cultivating learning via peer support.

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 transformation of oneself and one's peers 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. working together with a TD peer and having a Charades-like game 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:

A. GuessMe Improvements

Customisation

By letting the children design their own entity masks to be augmented on their peers, they will be able to work on their creativity and imagination for pretence. Also, this ensures that the game will not run out of 'rounds' as the children are in charge of creating them, making it re-playable. Moreover, it would also be fun for the children.

Support for giving hints

Giving video aides as action hint support when the child does not know how to act out may help teach children how to act via imitation. Other types of support for giving hints may also help. For example, asking the player questions which request specific actions like "What do *the entity* do most?" or "How does *the entity* walk?".

B. Free Play

Another area to explore is to develop an AR tool for free play sessions between children with ASC and his/her TD peer by letting the children choose their own augmentations and their own objects on which they would like to augment (i.e. toy objects or wooden blocks). This encourages learning through exploration which has already been proven to be effective in a supervised environment with TD peers (Wolfberg, 2012). Thus, it would be interesting to test the impact of AR in similar studies.

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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 tester.

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

I can decide to stop taking part or take a break if I want to.

I do not have to say why.

It is okay if I change my mind later, and say I do not want to be a games tester anymore.

It is okay 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 tester? YES NO

Mai Anh, Nicole, Orisa, Stasi, Nicholas, Tara, Aurora and Helen will listen to/watch the recordings later. They may show them to other people who make games for children.

Is it okay to take audio recordings? YES NO

Is it okay to take video recordings? YES NO

Write your name: _____

THANK YOU!

APPENDIX B

Research permission form (for parents)

	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 tester.

With reference to further anonymous use of video and audio data, please circle yes or no in response to the following (note: even if you say 'No' to this, your child can still participate in the study, but the video and audio data will only be seen by the research team):

I AGREE that short recordings 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 this. 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: _____

Signature:

Date: _____ /_____/__

APPENDIX C

Designing and testing games to help children

(to be read aloud to the child)

This page is for children. We will ask you to help design and test new computer games, take part in different activities, and answer a few questions. You can decide if you want to say “yes” or “no” to helping, and can change your mind at any time.

Who is organising the event? This is Helen and Orisa. They want to make computer games that can help children. You can help them by providing ideas for new computer games, taking part in different activities, helping test them, and answering some questions.

How can I help?

Orisa has created a game to encourage children with difficulties to take part in 'pretend play', where they might pretend to be someone else - perhaps an animal or a character from a story. This uses something called 'augmented reality', where a tablet or phone can help you to imagine that something looks different from what it really is. You will help test the game.

What will happen if I help? You will get to take part in game testing workshops and participate in other activities. You can tell Helen or one of the researchers if you want to stop doing any of the activities. You do not have to tell them why. Please tell them if you want to take a break. You can also say you do not want to be a game tester any more, and that is OK.

The researchers will ask if it is OK to make an audio or video recording of you helping design the game, and answering questions. This is because it is too hard for them to write down everything that happens. They will listen to and look at the recordings later to help them understand what you thought about the game.

What will happen after I am finished helping? The things you make, do and say in the game testing workshops will help them. They will write about what they have learned, and use it to evaluate their games.

Your mum or dad said it is OK for you to help us.
Do you want to be a games tester? 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 tester? It is OK to have more questions. You can ask the researchers 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

Testing Educational Games for Children with Autism

Information sheet for parents and guardians

This information sheet is for parents and guardians; it 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:

- Orisa Ngampakdeepanich, lead researcher, s1309783@sms.ed.ac.uk; 07895863725
- Prof. Helen Pain, research advisor, helen@inf.ed.ac.uk, 07974 971 475

University of Edinburgh, School of Informatics

Please return the parent consent form to one of the researchers if you give permission for your child to participate in the project. Note that if you completed the consent for game design in November, you do not also need to return this consent form.

Overview of the project

I am an UG5 student from the University Of Edinburgh working on educational games for children with autism as a part of our Honours projects.

What is the goal of the project?

We are investigating how to design an effective social game to teach children with ASC how to pretend play. 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. To encourage more spontaneous pretend play in children with ASC, we will be incorporating augmented reality and social support into a tablet game to expand their imagination and improve their cooperative play skills.

What is the purpose of the workshop?

The workshop will test how children respond to the game mechanics, i.e. the ‘charades’ component (guessing game) and the augmented reality, and other aspects of the game.

How can my child help?

The game testing workshops will comprise a variety of activities, including testing versions of the games developed, giving feedback on them, and making suggestions for improvements.

Workshop Information

What happens during the workshop?

Workshops will take place in the Brownies' meeting hall, Your child will get to play with the game prototype and provide feedback through related activities for c. 30 minutes. If your child is willing to talk to us about the activities, we will ask them a few questions. They will each participate in two workshops, if they are happy to do so.

Video and audio recordings

We would like to either video or audio 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 are not comfortable with your child being audio (and possibly video) recorded 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).

Can I have a copy of the games?

The game prototypes your child would play with in this study are merely proof-of-concept; that is, they are pieces of research software 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 some of 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 make an informed decision about whether participation as a game designer is a good idea for your child.

If you say "yes" when returning the permission form, we will explain the game tester role to your child, and ask them if they want 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 (and possibly video) 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 ask your child to be a games tester.

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?

_____

THE END

WELL DONE!

Game Art Sources

Sites are all accessed on January-February 2018

All graphics and sounds are loyalty free.

Images and Sound	Uploader: Link
Cat	San Yang: http://sanyangfrp.com/free-cat-photos.html
Game music	Ben: https://www.bensound.com
Village background	Clipground: http://clipground.com/image-post/79339-japan-house-clipart-6.jpg.html
Elephant	Oretha Boeding: http://www.nmgncp.com/free-baby-elephant-wallpaper/4673060.html
Clown	PNGTree: https://pngtree.com/freepng/circus-clown-design_3454412.html
Pirate	freedesignfile: http://all-free-download.com/free-vector/download/set-of-pirates-design-elements-vector-art_571361.html
Astronaut helmet	Sosseafest: http://www.sosseafest.org/6399/astronaut-helmet-clipart-03-11-2017/
Astronaut	Pexels: https://www.pexels.com/photo/sky-earth-space-working-2156/
Magician	PngTree:https://pngtree.com/freepng/vector-hand-painted-magician_3395516.html
Mermaid	4vector: https://4vector.com/free-vector/cartoon-mermaid-02-vector-94392
Unicorn	Clipart: http://clipart-library.com/clipart/1546195.htm
Santa	Clipart: http://clipart-library.com/santas-cliparts.html
Ninja	PNGTree: https://pngtree.com/freepng/vector-painted-masked-ninja_1708902.html
Group of animals	WorldArtsMe: http://worldartsme.com/group-of-animals-clipart.html#gal_post_4523_group-of-animals-clipart-1.jpg
Group of people	FreePik: https://www.freepik.com/premium-vector/professionals-wearing-their-uniforms_979025.htm
Magical animals	LaoBlogger: http://laoblogger.com/mythical-creatures-clipart.html#gal_post_138717_clipart-fantasy-art-8.jpg
Viking	PNGTree,https://pngtree.com/freepng/cartoon-vikings_3509435.html
Bee	Plasticdiamond: https://www.pinterest.com/pin/50665564535563549/