A World of Images

by
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ABSTRACT:

This thesis aims to improve autistic spectrum disorder therapy for children through the use of augmented reality. Specific points of reference are: signs and symptoms, actual learning processes and technology for their treatment. Interaction between children with autism and their parents or others can be difficult. However autistic children can have a natural talent and enjoyment for interaction with new technological devices. Gaining insight into how autistic children may prefer technology interaction over interaction with people, has led me towards the development of a new interactive AR (augmented reality) based tool for enhancing the relationship between therapists/parents and the child. AR provides the possibility of having 3D modelling, sounds, images and much more at the same time for customised modes of engagement and interest. Undertaken with user testing and evaluation, the research provides insights into how technology opens new doors in improving the quality of life for children with ASD.

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Finally I would like to thank Dr. Henry Moller and his clinic PRAXIS Holistic Health for making possible my connection with my principal user.

Dedication

To my family, without their support this thesis wouldn't be a reality.

To Jessica and Tamara for opening the doors of their personal experiences to me.

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1. Introduction

1.1 Motivation for undertaking the research

I am an Industrial designer with a secret passion for medicine and health. I am also a designer that loves to create new products, or just ideas for people with different capabilities. People with different capabilities are strong people that can do the same or even more than us with less, and this makes them unique.

In my family, health practitioners surround me. Doctors, nurses and physiotherapists are part of my family and while I was growing up I was capable to see how they helped other people and felt glad about it. I knew that I also wanted to help other people but in a more creative way and years later was when I discovered design, just the perfect match!

This love got stronger when I was doing my undergraduate program back in Colombia. I took two (2) semesters of Design for people with different capabilities. This period of time opened my eyes to a completely new perspective of the uses of the design and at the same time opened my mind to understand in a deep way some of the most common medical conditions that needs specific design such us mobility impairment, blindness and deafness. My undergraduate program thesis was a project developed for blind people. I created an accessory for the white cane that would allow people with visual impairment access to different cultural events in the city of Bogotá, Colombia. The white cane worked with a color sensor, a modular floor and Bluetooth earphones. Essentially this is how it

worked:

With the modular floor different paths for the cultural event will be created. Some of this modules will have a specific color, each color will represent a point of interest such us food court, washroom or information desk. The color sensor will detect the color and transform this data into a voice message delivered to the user using a Bluetooth earphone.

During my undergraduate studies I didn't have the opportunity to work with people with different cognitive conditions and now that I'm doing my masters degree I see the perfect opportunity to apply what I have learned on this.

1.2 Thesis Background

Different thinkers, this is what this world has, but not all people can see it. The mind and its own functionality is still somewhat uncertain, something that generates curiosity and the continuous search for understanding. Not that all minds work the same way; some minds learn more easily different types of activities or tasks, which leads to people who excel in different aspects, some better than others in different operations.

That is why in everyday life there are people with great skills – for example on an artistic level – while others are extremely impressive at mathematics or physical labour. Just as some amazing and beautiful landscapes are painted, some calculations are performed in an amazing and surprising way. But, what is the reason for that?

Awarded the Nobel Prize in Psychology or Medicine in 1981, Roger Sperry conducted a few experiments during the 1960s titled *The Split Brain*, which led to a better understanding of brain hemispheres and its functionality. According to Sperry's studies, Sperry, R. (2003, October 30). The Split Brain Experiments. (2015); the brain is divided into two hemispheres, the right one and the left one; each specialized in different tasks. The left side of the brain is normally specialized in taking care of the analytical and verbal tasks, speaking much better than the right side. The right half takes care of the space perception tasks, art and music, for example. Depending on the most used hemisphere, people's affinity for different tasks will be defined. We all have a predominant hemisphere. The question that arises is, what happens when a person's hemisphere doesn't work the way it is supposed to?

As mentioned at the beginning, the world is full of different kinds of thinkers, and one of these groups of thinkers, outside the "normal" range, is the autistic thinker. In the same way each individual is different from one to another, ours minds works differently; specially if we talk about the autistic mind.

The autistic mind is complex but fascinating at the same time. It is a mind that early in its life presented a typical development, but then something at some point of the child's life makes it lost normal functionality and became an autistic mind. It is still unknown what activates this change, according to the study Causes and Risk Factors. (2014, November 12) we do not know all of the causes of ASD. However, there are different factors that make a child more likely to have an

ASD, including environmental, biologic and genetic factors. With the advancement of science and medicine some studies and treatments have advanced too in order to lead to a better quality of life for people living with the syndrome and also for their own families.

Treatment at an early stage once the syndrome is discovered is essential for the person in order to have the best outcome and also to adapt more easily to the life routine. Now that technology gives us many tools for different purposes these treatments and learning processes can go further.

In this thesis I will consider the autistic syndrome and what it entails, and I will explore whether technology can provide a new an interactive tool to help children with this syndrome to improve in their daily tasks and activities during their therapy sessions.

2. Autism Spectrum Disorder

Autism spectrum disorder is the main topic of this Project. The tool created will be a tool developed specifically for a child with ASD.

According to *The Encyclopedia of Psychology* (2000), "Autism Spectrum Disorder (ASD) is a behavioural syndrome of neurologic dysfunction, characterized by impaired reciprocal social interactions, impaired verbal and nonverbal communication, impoverished or diminished imaginative activity, and a markedly restricted repertoire of activities and interests relative to age."

According to a study from the Autism and Developmental Disabilities Monitoring (ADDM) Network, Data & Statistics. (2008, January 1):

- About 1 in 68 children has been identified with autism spectrum disorder (ASD) according to estimates from CDC's Autism and Developmental Disabilities Monitoring (ADDM) Network.
- ASD is reported to occur in all racial, ethnic, and socioeconomic groups.
- ASD is almost 5 times more common among boys (1 in 42) than among girls (1 in 189).
- Studies in Asia, Europe, and North America have identified individuals with ASD with an average prevalence of about 1%. A study in South Korea reported a prevalence of 2.6%.
- About 1 in 6 children in the United States had a developmental disability in

2006-2008, ranging from mild disabilities such as speech and language impairments to serious developmental disabilities, such as intellectual disabilities, cerebral palsy, and autism.

2.1 Signs and Symptoms

The Centers for Disease Control and Prevention (CDC) and its analysis about Signs and Symptoms. (2014, March 20) has classified the ASD as follows: A diagnosis of ASD now includes several conditions that used to be diagnosed separately: autistic disorder, pervasive developmental disorder not otherwise specified (PDD-NOS), and Asperger syndrome. These conditions are now all called autism spectrum disorder.

ASD begins before the age of 3 and last throughout a person's life, although symptoms may improve over time. Some children with ASD show hints of future problems within the first few months of life. In others, symptoms may not show up until 24 months or later. Some children with ASD seem to develop normally until around 18 to 24 months of age and then they stop gaining new skills, or they lose the skills they once had. Studies have shown that one third to half of parents of children with an ASD noticed a problem before their child’s first birthday, and nearly 80%–90% saw problems by 24 months of age.

It is important to note that some people *without* ASD might also have some of these symptoms. But for people with ASD, the impairments make life

very challenging.

Possible "Red Flags" according to Signs and Symptoms (2014, March 20):

A person with ASD might:

- Not respond to their name by 12 months of age
- Not point at objects to show interest (point at an airplane flying over) by 14 months
- Not play "pretend" games (pretend to "feed" a doll) by 18 months
- Avoid eye contact and want to be alone
- Have trouble understanding other people's feelings or talking about their own feelings
- Have delayed speech and language skills
- Repeat words or phrases over and over (echolalia)
- Give unrelated answers to questions
- Get upset by minor changes
- Have obsessive interests
- Flap their hands, rock their body, or spin in circles
- Have unusual reactions to the way things sound, smell, taste, look, or feel

According to Signs and Symptoms. (2014, March 20) besides these red flags there are other symptoms in specific areas of human conduct as Social Skills, communication and unusual interests and behaviours. These are summarized below:

Social Skills

Social issues are one of the most common symptoms in all of the types of ASD. People with an ASD do not have just social "difficulties" like shyness. The social issues they have cause serious problems in everyday life.

Examples of social issues related to ASD:

- Does not respond to name by 12 months of age
- Avoids eye-contact
- Prefers to play alone
- Does not share interests with others
- Only interacts to achieve a desired goal
- Has flat or inappropriate facial expressions
- Does not understand personal space boundaries
- Avoids or resists physical contact
- Is not comforted by others during distress
- Has trouble understanding other people's feelings or talking about own feelings

Typical infants are very interested in the world and people around them. By the first birthday, a typical toddler interacts with others by looking people in the eye, copying words and actions, and using simple gestures such as clapping and waving "bye bye". Typical toddlers also show interests in social games like peek-a-boo and pat-a-cake. But a young child with an ASD might have a very hard time learning to interact with other people.

Some people with an ASD might not be interested in other people at all. Others might want friends, but not understand how to develop friendships. Many children with an ASD have a very hard time learning to take turns and share—much more so than other children. This can make other children not want to play with them.

People with an ASD might have problems with showing or talking about their feelings. They might also have trouble understanding other people's feelings. Many people with an ASD are very sensitive to being touched and might not want to be held or cuddled. Self-stimulatory behaviours (e.g., flapping arms over and over) are common among people with an ASD. Anxiety and depression also affect some people with an ASD. All of these symptoms can make other social problems even harder to manage.

Communication

Each person with ASD has different communication skills. Some people can speak well. Others can’t speak at all or only very little. About 40% of children with an ASD do not talk at all. About 25%–30% of children with ASD have some words at 12 to 18 months of age and then lose them. Others might speak, but not until later in childhood.

Examples of communication issues related to ASD:

- Delayed speech and language skills
- Repeats words or phrases over and over (echolalia)
- Reverses pronouns (e.g., says "you" instead of "I")

- Gives unrelated answers to questions
- Does not point or respond to pointing
- Uses few or no gestures (e.g., does not wave goodbye)
- Talks in a flat, robot-like, or sing-song voice
- Does not pretend in play (e.g., does not pretend to "feed" a doll)
- Does not understand jokes, sarcasm, or teasing

People with ASD who do speak might use language in unusual ways. They might not be able to put words into real sentences. Some people with ASD say only one word at a time. Others repeat the same words or phrases over and over. Some children repeat what others say, a condition called echolalia. The repeated words might be said right away or at a later time. For example, if you ask someone with ASD, "Do you want some juice?" he or she might repeat, "Do you want some juice?" instead of answering your question.

Although many children without an ASD go through a stage where they repeat what they hear, it normally passes by three years of age. Some people with an ASD can speak well but might have a hard time listening to what other people say.

People with ASD might have a hard time using and understanding gestures, body language, or tone of voice. For example, people with ASD might not understand what it means to wave goodbye. Facial expressions, movements, and gestures may not match what they are saying. For instance, people with an

ASD might smile while saying something sad.

People with ASD might say "I" when they mean "you," or vice versa. Their voices might sound flat, robot-like, or high-pitched. People with an ASD might stand too close to the person they are talking to, or might stick with one topic of conversation for too long. They might talk a lot about something they really like, rather than have a back-and-forth conversation with someone. Some children with fairly good language skills speak like little adults, failing to pick up on the "kid-speak" that is common with other children.

Unusual Interests and Behaviours

Many people with ASD have unusual interest or behaviours. Examples of unusual interests and behaviours related to ASD:

- Lines up toys or other objects
- Plays with toys the same way every time
- Likes parts of objects (e.g., wheels)
- Is very organized
- Gets upset by minor changes
- Has obsessive interests
- Has to follow certain routines
- Flaps hands, rocks body, or spins self in circles

Repetitive motions are actions repeated over and over again. They can

involve one part of the body or the entire body or even an object or toy. For instance, people with an ASD might spend a lot of time repeatedly flapping their arms or rocking from side to side. They might repeatedly turn a light on and off or spin the wheels of a toy car. These types of activities are known as self-stimulation or "stimming."

People with ASD often thrive on routine. A change in the normal pattern of the day—like a stop on the way home from school—can be very upsetting to people with ASD. They might "lose control" and have a "melt down" or tantrum, especially if in a strange place.

Some people with ASD also may develop routines that might seem unusual or unnecessary. For example, a person might try to look in every window he or she walks by a building or might always want to watch a video from beginning to end, including the previews and the credits. Not being allowed to do these types of routines might cause severe frustration and tantrums.

According to Signs and Symptoms. (2014, March 20) besides the above mentioned symptoms, people with ASD may have additional ones that might include:

Other Symptoms

- Hyperactivity (very active)
- Impulsivity (acting without thinking)

- Short attention span
- Aggression
- Causing self injury
- Temper tantrums
- Unusual eating and sleeping habits
- Unusual mood or emotional reactions
- Lack of fear or more fear than expected
- Unusual reactions to the way things sound, smell, taste, look, or feel

People with ASD might have unusual responses to touch, smell, sounds, sights, and taste, and feel. For example, they might over- or under-react to pain or to a loud noise. They might have abnormal eating habits. For instance, some people with an ASD limit their diet to only a few foods. Others might eat non-food items like dirt or rocks (this is called pica). They might also have issues like chronic constipation or diarrhea.

People with ASD might have odd sleeping habits. They also might have abnormal moods or emotional reactions. For instance, they might laugh or cry at unusual times or show no emotional response at times you would expect one. In addition, they might not be afraid of dangerous things, and they could be fearful of harmless objects or events.

Development

According to Signs and Symptoms. (2014, March 20, children with ASD

develop at different rates in different capacities. They may have delays in language, social, and learning skills, while their ability to walk and move around are about the same as other children their age. They might be very good at putting puzzles together or solving computer problems, but they might have trouble with social activities like talking or making friends. Children with an ASD might also learn a hard skill before they learn an easy one. For example, a child might be able to read long words but not be able to tell you what sound a "b" makes.

2.2 Learning Process

There are no medications or treatments that can cure completely ASD, but there are some therapies than can help to improve this condition. The critical points to work with are behaviour and communication skills.

The CDC and its Behavior and Communication Approaches. (2014, March 3) explains the different approaches for the therapy and learning process of children with ASD as follows:

2.2.1 Therapy

2.2.1.1 ABA (Applied Behaviour Analysis)

A notable treatment approach for people with an ASD is called *Applied Behaviour Analysis* (ABA). ABA has become widely accepted among health care professionals and used in many schools and treatment clinics. ABA encourages positive behaviours and discourages negative behaviours in order to improve a variety of skills. The child’s progress is tracked and measured.

There are different types of ABA:

- Discrete Trial Training (DTT)

DTT is a style of teaching that uses a series of trials to teach each step of a desired behaviour or response. Lessons are broken down into their simplest parts and positive reinforcement is used to reward correct answers and behaviours. Incorrect answers are ignored.

- Early Intensive Behavioural Intervention (EIBI)

This is a type of ABA for very young children with an ASD, usually younger than five, and often younger than three.

- Pivotal Response Training (PRT)

PRT aims to increase a child's motivation to learn, monitor his own behaviour, and initiate communication with others. Positive changes in these behaviours should have widespread effects on other behaviours.

- Verbal Behaviour Intervention (VBI)

VBI is a type of ABA that focuses on teaching verbal skills.

2.2.1.2 Complementary therapies

- Occupational Therapy

Occupational therapy teaches skills that help the person live as independently as possible. Skills might include dressing, eating, bathing, and relating to people.

- Sensory Integration Therapy

Sensory integration therapy helps the person deal with sensory information, like

sights, sounds, and smells. Sensory integration therapy could help a child who is bothered by certain sounds or does not like to be touched.

- Speech Therapy

Speech therapy helps to improve the person's communication skills. Some people are able to learn verbal communication skills. For others, using gestures or picture boards is more realistic.

- The Picture Exchange Communication System (PECS)

PECS uses picture symbols to teach communication skills. The person is taught to use picture symbols to ask and answer questions and have a conversation.

2.2.2 Reward-based learning (reinforcement)

According to Berridge, K. (2000) reinforcement: the idea that reward learning consists primarily of a process by which behaviour is directly strengthened or weakened by the consequence that follows it. Reinforcement is alive and strong as a concept in psychology. Certain neural structures, called the **reward system**, are critically involved in mediating the effects of reinforcement. A reward is an appetitive stimulus given to a human or some other animal to alter its behaviour. Rewards typically serve as reinforcer.

According to Volkow (2007), a reinforcer is something that, when presented after a behaviour, causes the probability of that behaviour's occurrence

to increase. Note that, just because something is labelled as a reward, it does not necessarily imply that it is a reinforce. A reward can be defined as reinforce only if its delivery increases the probability of behaviour.

Moran, M. (2008, January 15) argues that reward or reinforcement is an objective way to describe the positive value that an individual ascribes to an object, behavioural act or an internal physical state. Primary rewards include those that are necessary for the survival of species, such as food.

According to autistic behaviour therapist Angela Aguirre, reinforcement is always present at the different sessions and stages of the child's therapy. But, the reinforcement for autistic children doesn't works the same way it would do with non-autistic.

According to the *Effective Educational Practices for Students with Autism Spectrum Disorders, 2007,* rewards for autistic children are categorized as follows:

- **Toys and Trinkets**

  Balloons, spinning tops, drums, plastic bottle filled with coloured water and sparkles, elastic putty, blocks, stickers, and so on.

- **Sports/Physical**

Flips, twirls, spins (on chairs), hugs, high-fives, low-fives, pat on the back, piggyback rides, crawl on the floor, running, and so on.

- **Food**

Small candies, pop, juice, ice cream, fruit, pretzels, popcorn, crackers, and so on.

- **Social**

Enthusiastic verbal praise, smiles, thumbs-up, applause, wink, sing a song, blow a kiss, raise your arms and shout “Hooray”, and so on.

- **Recreation/Entertainment**

Watch a video, hide and seek, colouring, freeze dance, blow bubbles, play cards, and so on.

- **Community**

Go to a movie, go to a restaurant, go shopping, go swimming, visit friends and/or family, go to the park, go for a walk, and so on.

As it was mentioned before, each child is different so each reaction would be different. That’s why the reinforcement must be given according to each child’s condition and preferences.

2.2.3 Therapeutic approach taken by this research

In this project, the reinforcement will be still in use as part of the therapy in order to keep children motivated after they achieved a task, always having in mind that this reward will be according to the children own preferences. The therapist and the parents will be the ones selecting the type of reward for each child because they are the ones that have a clear idea of their desires. The different therapies' tools will be analyzed with the help of a behaviour therapist in order to define the best one to work with, and the user will be the key to define the symptoms and activities to improve.

3. Technology as part of the autism therapy

Technology is already being used in the autistic world. This chapter will explore relevant uses of technology that are being use to improve ASD condition and the technology this project is exploring.

3.1 Current technological therapies / tools

3.1.1 Snoezelen Rooms

Snoezelen or controlled multisensory environment (MSE) is a therapy for people with autism and other similar health condition. It consists of placing the person in a soothing and stimulating environment, called the "Snoezelen room". These rooms are specially designed to deliver stimuli to various senses, using lighting effects, color, sounds, music, scents, etc. The combination of different materials on a wall may be explored using tactile senses, and the floor may be adjusted to stimulate the sense of balance. An aide or therapist usually accompanies the person.

Figure 1 Snoezelen room, Snoezelen, 2014

History of Snoezelen MSE therapy. (2005, November 29) tells that these rooms were originally developed in the Netherlands in the 1970s, Snoezelen rooms have been established in institutions all over the world and are especially common in Germany, where more than 1,200 exist. The term "Snoezelen" is a neologism formed from a blend of the Dutch "snuffelen" (to seek out, to explore) and "doezelen" (to doze, to snooze). "Snoezelen" is a registered trademark of the English company Rompa that sells equipment for Snoezelen rooms.

Figure 2 Snoezelen room, Snoezelen, 2014

3.1.2. Popchilla's World

Popchilla's world is an interactive game created and developed by Interbots in partnership with the Barber National Institute, Pittsburg Penguins Foundation and the Children's Institution, where a robot works together with an iPad as an autism therapy tool. This game was designed to help children with ASD practice daily routines and social interactions in a fun and playful way.

In the game, a friendly creature named "Popchilla" needs the child's help to navigate the world and complete simple activities like brushing Popchilla's teeth, making Popchilla's bed, or saying hello. As the child completes these activities they are rewarded with in-game achievements and new activities to explore.

Figure 3 Popchilla's World. Interbot, 2012

Figure 4 Popchilla's World. Interbots, 2012

The activities on the app work mostly by clicking or by grab and drop actions. The interaction between the robot and the iPad app is simple. The user will select, for example, a facial expression and the robot will do the expression.

Figure 5 Popchilla's World. Interbots, 2012

3.2 Technology used in *A World of Images* project

3.2.1 From an App idea to an AR project

At the beginning of the creative process, the idea was to build an app, but the research about current technological tools, referring specifically about apps, showed that there are already many apps in the market making this project to look for a solution beyond a regular app. The project can go further using AR (augmented reality). Why AR? Because AR can give the children a new tool that will allow them to interact with images, sounds, videos, animations and 3D objects at the same time.

3.2.2 Augmented Reality (AR)

It is a live direct or indirect view of a physical, real-world environment whose elements are *augmented* (or supplemented) by computer-generated sensory input such as sound, video, graphics or GPS data. According to Graham, M., Zook, M., & Boulton, A. (2013) it is related to a more general concept called mediated reality, in which a view of reality is modified (possibly even diminished rather than augmented) by a computer. As a result, the technology functions by enhancing one's current perception of reality. Steuer, J., Biocca, F., & Levy, M. (1995) argued that by contrast, virtual reality replaces the real world with a simulated one. Augmentation is conventionally in real-time and in semantic context with environmental elements, such as sports scores on TV during a match.

With the help of advanced AR technology (e.g. adding computer vision and object recognition) the information about the surrounding real world of the user becomes interactive and digitally manipulable. According to Chen B. (2009) artificial information about the environment and its objects can be overlaid on the real world.

Figure 6 AR EdiBear game, 2011

4. Methodology and Design

4.1 Research Question

My research question is:

How can an interactive digital tool help children with autism spectrum disorder (ASD) facilitate and improve their daily learning and activities?

In this section I describe the research methodology and design that I use to answer this research question in detail.

4.2 Overview

A World of Images aims to create an augmented reality toolkit that helps to improve the daily learning and activities of children with autism spectrum disorder in a new and fun way. This project explores the potentiality of AR as a new tool for the therapy, bringing together images, sounds and 3D models in the actual flash cards that the therapist uses with the children. The interest of this thesis is to take advantage of the way people with ASD think to help them in their therapy by the use of a technological tool. *A World of Images* is a kit where therapists, parents and children will find three main topics, each of them related to an important part of their therapy process. The research for this project was divided into different stages from reading on the subject, watching videos including documentaries and conferences, talking to experts and family members and running hands-on experimentation according to the feedback collected.

4.3 Methodology

Defining and selecting the right design methodology was the key to have the correct user approach and feedback. The right methodology is crucial for a great project development. This is a project that works with a specific part of the population and that is why it needed to be user centered design.

4.3.1 User-Centered Design

User centered design was the methodology selected to work in the development of this project because I want to create a tool for a specific group of people. And even more important is that even in this group of people all of them have ASD, they are completely different one to each other. I needed to go deeper into their own individual needs in order to create the best solution for each of them. At some point I thought about inclusive design, but inclusive design talks about a design for everybody no matter their physical or cognitive condition, it talks about a universal design, but autism is so complex that one solution wont work for everybody. That is why I used user centered design, even I am working with one syndrome specifically, ASD, each individual has different needs.

The design of everyday objects is not always intuitive and at times it leaves the user frustrated and unable to complete a simple task. Abras, C., Maloney-Krichmar, D., Preece, J. (2004) define ‘User-centered design’ (UCD) as a broad term to describe design processes in which end-users influence how a

design takes shape. It is both a broad philosophy and variety of methods. There is a spectrum of ways in which users are involved in UCD but the important concept is that users are involved one way or another.

The term ‘user-centered design’ originated in Donald Norman’s research laboratory at the University of California San Diego (UCSD) in the 1980s and became widely used after the publication of a co-authored book entitled: User-Centered System Design: New Perspectives on Human-Computer Interaction (Norman & Draper, 1986).

Preece, J.; Rogers, Y., & Sharp, H. (2002) argued that its involvement in the process design leads to more effective, efficient and safer products and contributed to the acceptance and success of products.

In the table 1 Preece, J., Rogers, Y., & Sharp, H. (2002) suggests ways to involve users in the design and development of a product/artifact.

Technique	**Purpose**	**Stage of the Design Cycle**
Background Interviews and questionnaires	Collecting data related to the needs and expectations of users; evaluation of design alternatives, prototypes and the final artifact	At the beginning of the design project

Sequence of work interviews and questionnaires	Collecting data related to the sequence of work to be performed with the artifact	Early in the design cycle
Focus groups	Include a wide range of stakeholders to discuss issues and requirements	Early in the design cycle
On-site observation	Collecting information concerning the environment in which the artifact will be used	Early in the design cycle
Role Playing, walkthroughs, and simulations	Evaluation of alternative designs and gaining additional information about user needs and expectations; prototype evaluation	Early and mid-point in the design cycle
Usability testing	Collecting quantities data related to measurable usability criteria	Final stage of the design cycle
Interviews and questionnaires	Collecting qualitative data related to user satisfaction with the artifact	Final stage of the design cycle

Table 1: user centred design cycle

4.4 Main Topic Research Process

4.4.1. Selection of the topic to work with

During the entire process of the research for this work, many people asked "Why autism?" Or "Why such a complicated topic?" and actually the answer was another question for these people: "Why not?"

During my undergraduate program I had the opportunity to work with people with different disabilities, but at the end of my studies I realized that we never had the chance to work with cognitive disabilities; we were really focused on people with physical disabilities because it can be easier to understand and design for them. Working and understanding how the brain works and why sometimes it has abnormal behaviour is a challenging task, but I was completely sure and determinate to work with cognitive disabilities on my next big project.

So why autism? The curiosity about an unknown topic leads to start reading about it in order to a better understand of it. Every new article about autistic spectrum disorder was an article I needed to read.

And in this way is how my own curiosity and desire to help them facilitated the decision of choosing this topic for this project.

4.4.2 Understanding of the disability

After choosing a topic the next step was to understand it. A good design must have a good understanding and knowledge of its final user. One big advantage for me during the entire research and development process was to count with the feedback of the autistic behaviour therapist Angela Aguirre; her undergraduate program was in Special education and psychology, masters degree in Applied Behaviour Analysis and PhD in Clinical Psychology. She guided and helped me through bibliography, interviews, personal teaching experiences, feedback and insights. She was an important part of this process from the

beginning to the end.

4.4.3 Research about actual techniques

After having a better understanding about the main topic of the project, the next step was to find out about the actual techniques and tools that are being already used.

For the actual techniques used in the therapy I contacted Angela Aguirre. She explained the actual approach used from the moment a new child comes to the institution until how they defined the best way of learning for each of them. As it was mentioned before, each child is different in terms of their reactions and amount of time required to learn. Even all of them have the autistic spectrum disorder; they would never act or respond the same way even if the stimulus is the same.

For this project it was really important to know how technology is working to help these children to improve in their therapy. Even nowadays the therapist uses technological devices as the iPad, they don't really have a new and innovative technological tool. After doing the research about actual technological tools it was notorious how some parts of the therapy has evolved from the paper to some apps that users can use in these devices. There are apps for colors, for numbers, for sounds… apps for almost everything. This was a great insight that helped to understand that innovation in this project needed to be something more

than just a simple app. This project needed to be somehow better than a regular app. The Snoezelen Room and Popchilla's World, mentioned on chapter 3, are examples that goes beyond the simple app and are a good case of how technology can help in a greater way. I knew this project should follow that path where the user would feel more engaged and motivated to use the final product.

5 User of a World of Images

5.1 Users

The heart and soul of *A World of Images* are the users. This is a research project where the user was the main motivation to develop a great idea. But here, there is not just one user; the main final user is the child with autism but their parents and therapist are users too. Parents and therapist play an important role; they are a great support during the therapy and improvement of the children. But, how each of these users can benefit from the project?

- **Children:** They will have the opportunity to try a new and technological tool developed to help them in their daily process and activities. They will be working to improve using technology but having fun at the same time.
- **Parents:** They will see how their children improve and learn with the constant use of the kit. This will give them a feeling of satisfaction and happiness.
- **Therapist:** They will be able to make this kit part of their therapies and help more children and parents in their own process.

5.2 Therapist Interview

Currently, behaviour therapist for autistic children at the New Jersey Institute for Disabilities Angela Aguirre is working with eight children. The therapies are individual and each child is completely different from one to another.

On October 14 of 2014, the therapist Angela Aguirre was interviewed in order to understand ASD from a person that lives daily with this syndrome. For details about this interview please see the Appendix A: Therapist interview.

After this interview I knew I was in the right path. Her suggestions for the different activities opened the process of prototyping and experimentation.

5.3 Family Interview

Having the perspective of the therapist, it was time to gather some information from the family:

For details about this interview please see the Appendix B: Family interview.

This interview revealed that electronic devices are a good approach to children with ASD because they show interest in them; they need to keep working with the children inside and outside school and electronic devices achieve this

objective and finally, visuals and hands on are the better way to teach them and improve already known lessons.

6. Development

The development of the technological part of the project started with the selection of the software that could work better for the prototype. At the beginning of the design process the idea was to build and app and the software Game Salad seemed to be a good choice for this. The program worked fine but it didn't have the necessary tools for creating the desire experience. Before going further with the idea of an app, a research about already existing apps for ASD showed that the project needed a new idea to be developed using another more sophisticated software. The research also showed that until now there are no AR experiences for children with autism. This was an insight that transformed the project itself. After this insight a brainstorming started about how AR could be part of the project, how the markers that will trigger the experience will work and how this experience would be.

6. 1 Experimentation and Design Evolution

At the beginning of the creative process the idea was originally to build an app.

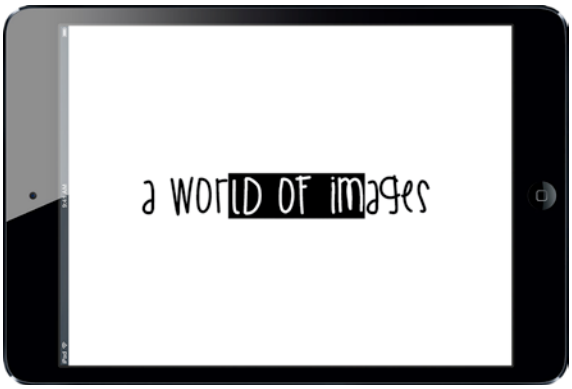

Figure 7 First prototype. Welcome page

After the welcome page users will find a menu where they will be able to choose between Agenda, My Agenda and Build.

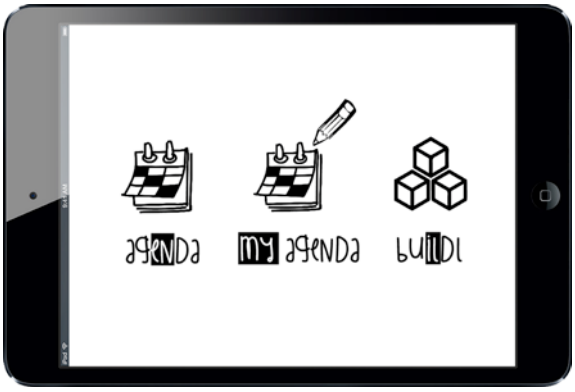

Figure 8 First prototype. Activities menu

In the first part of the app, called Agenda, the children would have the option to see their daily routine and its activities described step by step using images; when the image is clicked a voice will say the description about it.

Figure 9 First prototype. Routine screenshot

In the second part of the app, called My Agenda, children would have the opportunity to let know to their therapists or parents the activity they would like to do. This first section of the app worked with drag and drop actions.

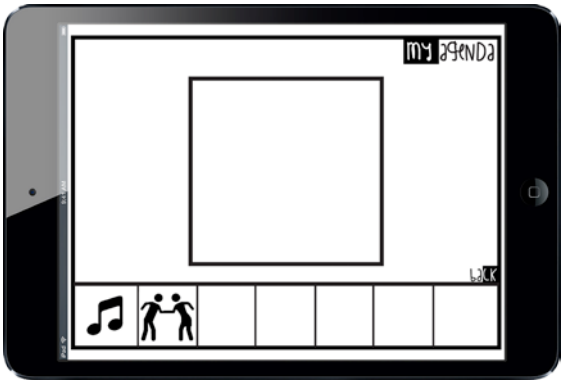

Figure 10 first prototype. Activity selection screenshot

The research about existing apps showed that there are many apps that already exist; this outcome made me rethink the first project idea in order to find a way to go beyond a regular app. The project can go further using AR (augmented reality) together with an iPad. During the research about existing technological

tools for autism, AR doesn't show up until this moment. I thought about AR because I worked with this tool for another project before this one.

Leaving behind the idea of just an app, *A World of Images* evolved into a kit. This kit has 3 main topics: Life skills, Fun activities and Education. Each of these main topics will have 3 different activities that the children will learn and/or improve step by step:

a) Life skills:

a. Take a shower

b. Get dress

c. Make the bed

b) Fun Activities:

a. Playing with the iPad

b. Turning on the TV

c. Using the DVD player

Education:

d. Animal's sounds

e. Facial Expressions

f. Numbers

All of these activities were selected with the guidance of the behaviour

therapist Angela Aguirre.

As it was already mentioned, the kit works with AR. Each activity will have between 8-10 flash cards (depending on the activity) and each of them would be a step or lesson to learn. These flash cards are actually markers that will trigger the experience. And each of the cards will be related to what they are going to show.

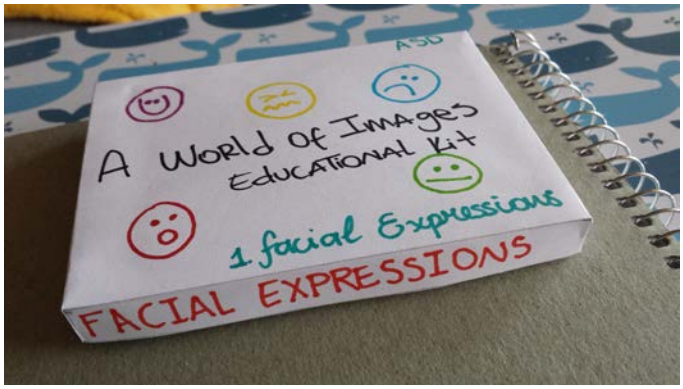

Figure 11 Second prototype. Education kit

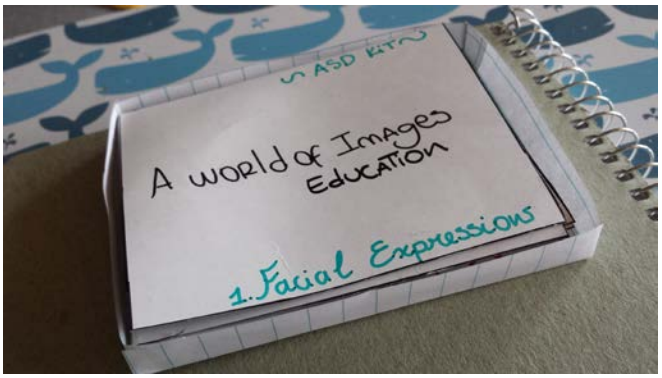

Figure 12 Second prototype. Facial expressions kit

Figure 13 Second prototype. Flashcards/markers

To understand how the kit works let's pick one of the activities, in this case Facial Expressions.

Inside the kit, there will be markers for the different facial expressions such us happy, sad, confused, scared… The therapist or one of the parents will pick up one of the markers and will interact with the iPad. When the iPad camera recognizes the marker it will show the facial expression on the screen.

Dealing with ASD children can be laborious, that is why it is important to keep the interaction in the less complicated way. The idea is to have an easy and fun interaction. That's why the first thought was to use the iPad's front camera; it could make the interaction easier because the person manipulating the device won't have to hold the marker, reach the back camera and take care of the child at the same time.

This person can just be seating with the child holding the marker in front

of the iPad and it will detect the marker.

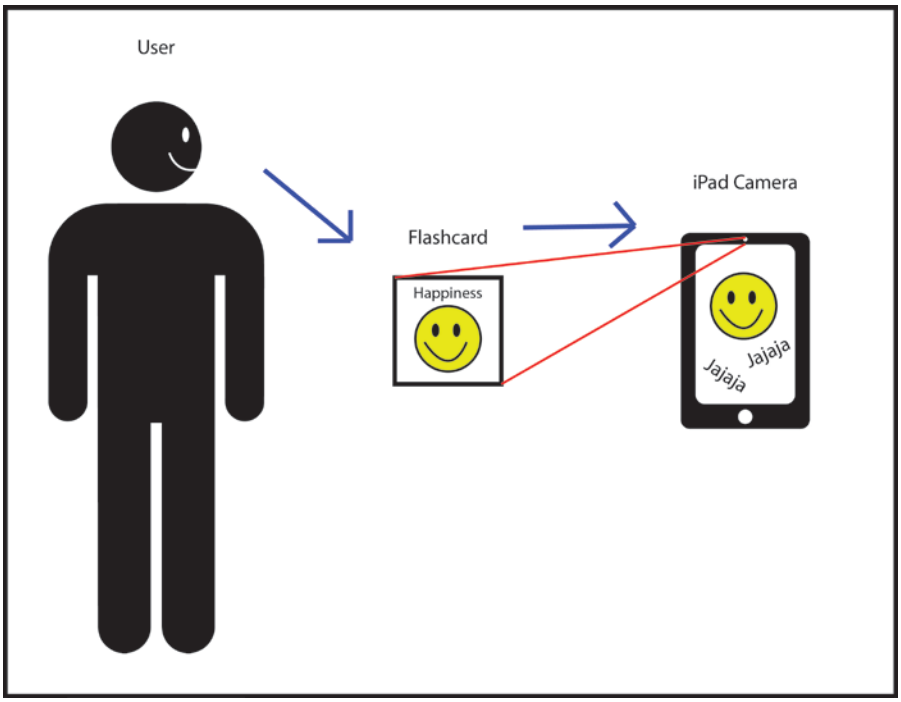

Figure 14 Interaction user+flashcard+iPad

In the same way the interaction between camera+user changed, the interaction between camera+marker must change too. That's why both sides of the markers would be used. The front side actually won't be a marker, it would be an image related to the step or lesson the kid will learn, and the backside of it would be the marker. As the parent or therapist hold the marker, the front side of it will show the kid (going back to the facial expressions example) a picture of a happy expression while the backside will show to the iPad the marker.

When the camera recognizes the marker it will show the facial expression

but not only with an image, it will also have sound, the user will be able to hear “this is my happy face!”, “when I’m happy I smile!”.

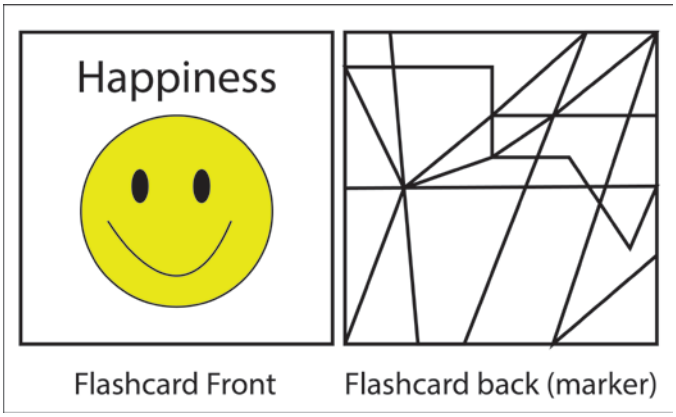

Figure 15 Front and back of flashcards

After talking and showing this prototype to the behaviour therapist the idea of using the front camera was discarded because according to her there is no need for that. They can use the kit in the same way they are already using the iPad for other activities; they use it sitting down on a table manipulating the iPad with the child. And this is actually better for the therapy because any small change for the children could generate stress or rejection.

A really important part of the therapy is the one that includes flash cards with images. Therapist uses the images to teach different topics to the children such as daily routine, animals, life skills (shower, getting dress...); they even use these flash cards for children that aren’t able to speak. These flash cards are the way, for some children, to communicate.

The actual flash cards have a size of 8x7 inches so this is the size that the project will be using for the kit. The idea of keep working with the actual size of

the cards is to not generate any big impact to the children because, as it was mentioned before, there are really sensitive to small changes. This would be the evolution of the actual flash cards.

Figure 16 Third prototype. Flashcards

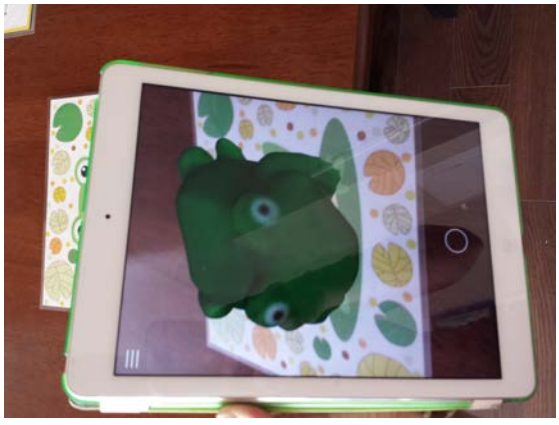

Figure 17 Third prototype. 3D frog with sound

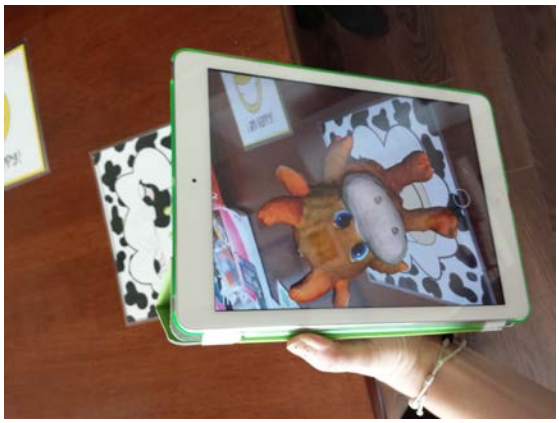

Figure 18 Third prototype. 3D cow with sound

6.2 Prototyping and Software

The first prototype of A World of Images was developed using the game creator software Game Salad. It was an app for iOS environment. After the first presentation to my peers and professors I decided to change this creator tool because it didn't allow me to do what I wanted to develop. This software only allowed me to do basic games/apps designs and I was looking to go beyond that.

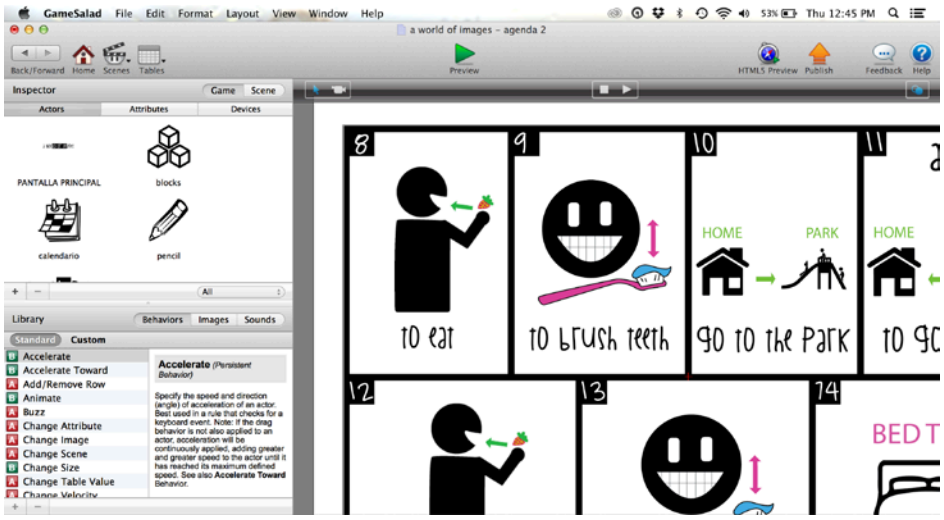

Figure 19 First prototype developed using GameSalad creator

For subsequent prototypes a 3D scanner was used. This was a Structure Sensor, compatible with iPad devices.

Figure 20 Structure Sensor, Structure, 2015

The 3D models obtained from the 3D scanner were retouched in Unity. Described by Riccitiello, John (2014), Unity is a cross-platform game creation system developed by Unity Technologies, including a game engine and integrated development environment (IDE). Unity Fast Facts (2014) show how it is used to develop video games for web sites, desktop platforms, consoles, and mobile devices. According to Brodkin, J. (2013, June 3) first announced only for Mac OS, at Apple's Worldwide Developers Conference in 2005, it has since been extended to target more than fifteen platforms.

After the 3D model was finished it was exported as a Unity package in order to import it to the AR experience creator.

Figure 21 3D model being retouched using Unity software

The AR experience was built in a 4D Studio called Daqri. The Daqri software has the tools to create and the technology to deliver augmented reality experiences.

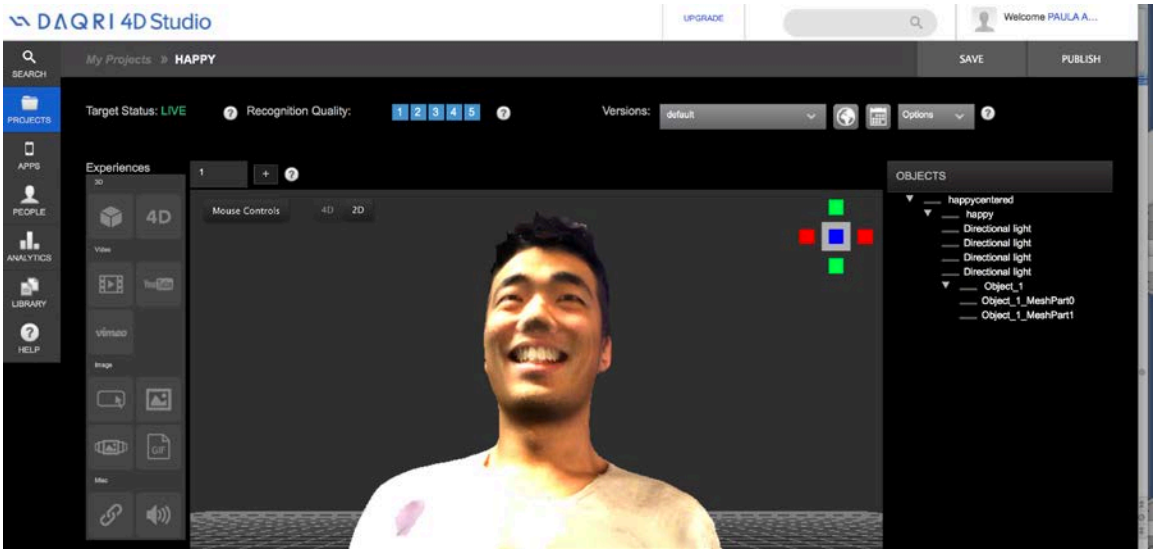

Figure 22 Creating the AR experience using the Daqri 4D Studio

And finally, the flashcards that triggers the AR experience were designed using Adobe Illustrator. These flashcards have the same size of the actual flashcards that are being used in the therapies.

Figure 23 Desing of the flashcards

Figure 24 Flashcard

6.3 The design of the experience for the user

The methodology for this project is user-centered design. The final part of the project was focused on Jessica, a child with autism presenting a high functional level. All of the insights and feedback gathered from her and her family gave the direction the project should follow to have a satisfactory result.

6.3.1 Meeting Jessica and her Family

Many times thinking I finally had found someone to participate in the testing but then seeing how this possibility vanished was really frustrating. I remember Tom Barker, my primary advisor, saying “Don’t panic yet!”. And he was completely right. At the last moment I had the great opportunity of meeting Jessica, the sweetest 16 year old girl with ASD and Tamara, her mom.

This process started on Feb 5th. Our interaction started with text messages. The text messages were between Tamara and myself. After a few messages we were ready for the next step, a phone call. This time I would first talk to Jessica and afterwards with her mom. I must admit that I was really nervous about this call basically because this was my first real interaction with someone with ASD. Her mom told me that it was possible she wouldn’t be able to understand what I was talking about but it was a good idea to give it a try. The day and time came; it was time for that first call. I called, but nobody answered, this was bad for my

nerves. After a couple of minutes I received a text message asking me to call again so I did it. Maybe because of that text message, sent by Tamara, I was expecting she would be the one on the other side. I called and I said “Hi Tamara” but the response was “Hi this is Jessica”.

To be honest I didn’t know what to say or how should I talk to her, so I just decided to start talking, asking how was she doing and then talking about the project. I notice that the questions “How are you?” or “How was your day?” were easily understandable for her but when I start talking about my project, especially about augmented reality, well, that was another story. And it was completely understandable because even when I tell my project to people without the syndrome they don’t easily understand what I’m talking about. This type of project should be shown in person for a better understanding. And so we planned a meeting the week after.

I was excited about this first meeting because it was the opportunity to gather great feedback and insights. I had in mind I would meet Jessica and her mom but her dad was also there. At the beginning this was somehow intimidating because he was a really serious person, but as soon as I started talking about the project and my motivations the meeting became enjoyable.

6.3.2 User Testing

The first functional prototype was ready and it was time to try it with its real user.

6.3.2.1 First Session

February 10th. The first part of the user testing started with the explanation of the project and how the prototype works. The first one trying it was Jessica's dad. He looked interested but at the same time doubtful. The place of the meeting didn't have good Wi-Fi connection and this was becoming a problem.

Thanks to this I realized that the prototype doesn't work without a good Wi-Fi signal. After some tries it finally worked. Jessica's dad was surprised and he showed what was happening on the iPad to Tamara, Jessica's mom. After they both saw how the prototype worked was Jessica's time to try it.

Figure 25 Jessica trying the prototype for the first time

After showing the prototype to Jessica and her family we started discussing what activities or lessons could be applied in the project according to her needs. As any other child with ASD, she already has an established routine which mostly of the time could be accomplished by herself. Her parents told me that it would be great for her to try to improve some aspects such us eating, cleaning the dishes after dinner and the consequences of her acts. The last one was actually really interesting; helping her to understand that good and bad behaviour has consequences.

At the end of the first meeting we defined how the first activity of the *A world of Images* kit would work for Jessica. Her parents wanted to improve her eating routine starting from having small bites of food until loading the dishwasher. The list of the activity steps was developed with Tamara's help as follows:

1. Small bites of food
2. Chewing with your mouth closed
3. Wipe face after eating
4. Well done you ate your food! (Verbal reinforcement)
5. Clear the dishes from the table
6. Rinse the dishes
7. Load the dishwasher

6.3.2.2 Work after session 1

Having defined the first part of the project was the first step to begin with the evolution of the prototype and the kit itself. The prototype showed to Jessica and her family was a prototype designed for autistic children in general, but now it was time to start designing for the main user of this project.

The work after the first session was focused on the AR experience. The design process started carefully thinking which was the best way to show Jessica the different steps of the activity. For some of the activity steps 3D modelling worked perfectly fine but for other steps animations and video worked better. All depended on what she was going to improve and the best way of giving that information to her; for example chewing with your mouth closed was easier to

understand with a video of how she should do it rather than a 3D modelling.

This time the 3D modelling was made with the Google software Sketchup. This easy to use software was a great tool to work with. It's a software that allows users to do 3D modelling in a faster and easier way than other more complex 3D programs will do.

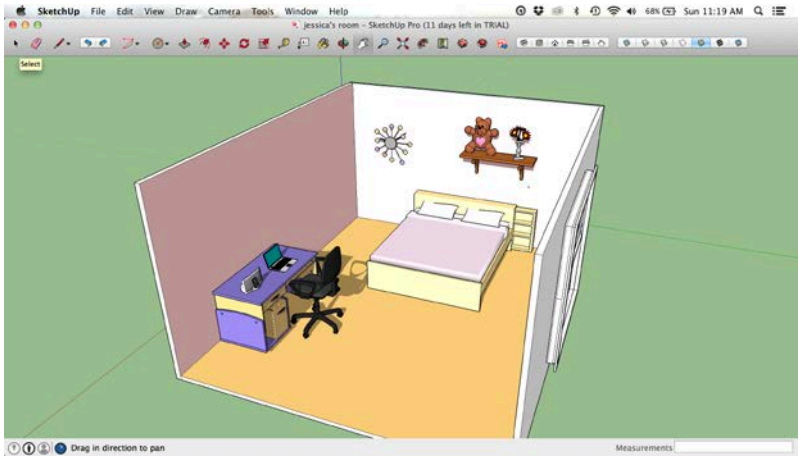

Figure 26 Sketchup software – Jessica's room

The next meeting for the second user test was a couple of days ahead so the flashcards were random images that will trigger the AR experience. The design and develop of the AR experience requires more time than the flashcards because it includes 3D modelling, video and animations.

With the prototype ready, according to Jessica and her family needs, it was time for the second session of user testing.

6.3.2.3 Second Session

February 27th. The purpose of this second user test meeting was to show progress, gather feedback and define future steps.

The beginning of the meeting was a reminder of last meeting. After all the participants were on the same page the user test began. As it was mentioned before, the flashcards for this user test meeting were not the finals one.

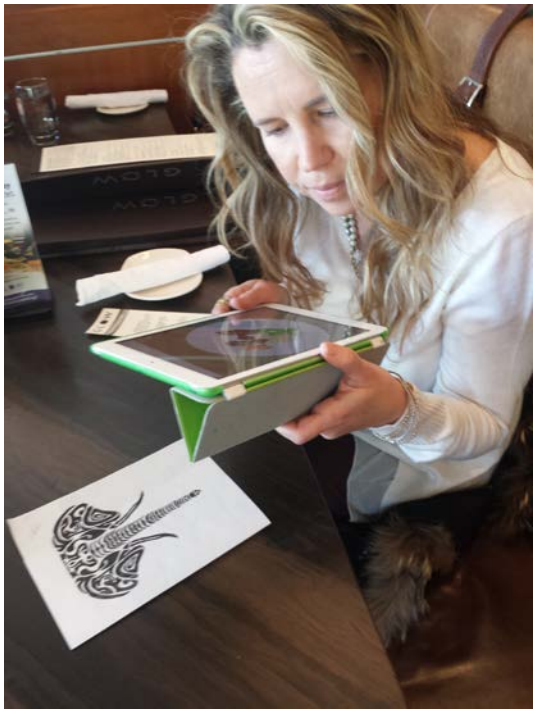

Figure 27 Tamara trying the new prototype

The results were satisfactory. The family was excited about this tool and they asked to take it home with them to start practicing with Jessica. Unfortunately, because of the flashcards, that was not possible at that time, but as

soon as the flashcards were ready they will be receiving them in order to start using the first part of the kit.

The experience was also showed to the behaviour therapist Angela Aguirre and these are her thoughts:

“Looks good. Falls under 2 different teaching categories of teaching a large skill and breaking into smaller steps. This could fall under a social story or task analysis, the breaking down of large task into smaller tasks.”

After having everything clear about this activity and its AR experience we started defining how the second part of the kit, behaviour and consequences, should work. Right now, Jessica’s school is implementing a new activity based on behaviours. Each behaviour will be represented by a color starting with green for a good behaviour, yellow for a behaviour that is not that bad but can be avoided and red for bad behaviour.

Jessica’s parents wanted to include this in the second part of the kit but because this activity is new at Jessica’s school we needed more time to see how it was developed in order to incorporate it to the project. During the meeting it wasn’t defined how it would work but it was decided that Tamara and myself would think about the best way to integrate it into the project while we gather more information about it.

6.3.2.4 Work after session 2

Design of flashcards that will trigger the AR experience of the first part of the project. The developed flashcards were random images that now needed to be related to the project. Jessica is able to read so Tamara asked to have some text on them as another way for her to practicing her reading skills.

New flashcards:

Figure 28 Small bites flashcard

Figure 29 Small bites AR experience

Figure 30 Chew with mouth closed and wipe face during meal flashcard

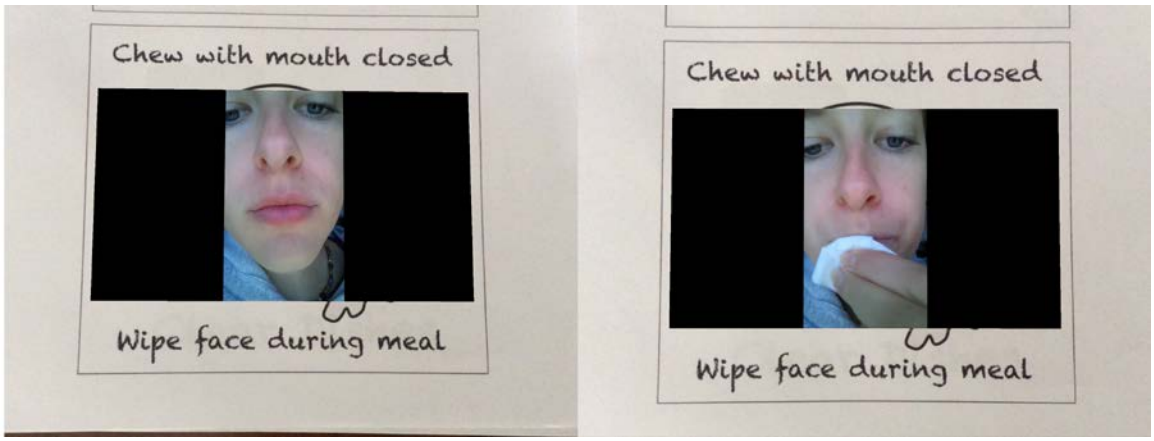

Figure 31 Chew with mouth closed and wipe face AR experience

Figure 32 Finish eating flashcard

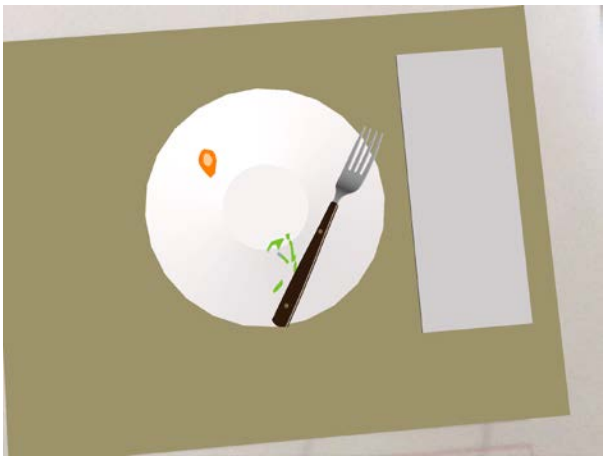

Figure 33 Finish eating AR experience

Figure 34 Clear dishes flashcard

Figure 35 Clear dishes AR experience

Figure 36Rinse dishes flashcard

Figure 37 Rinse dishes AR experience

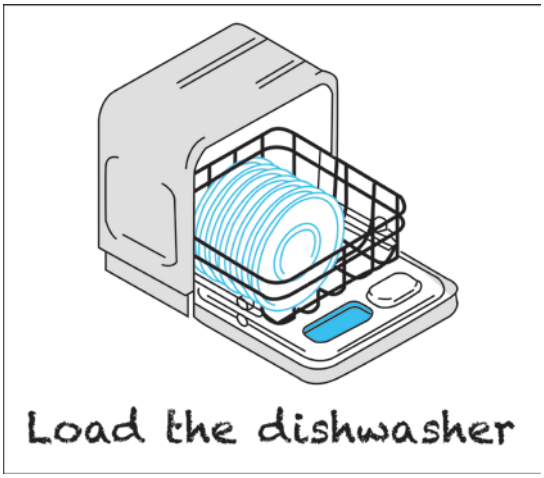

Figure 38 Load the dishwasher flashcard

Figure 39 Load dishwasher AR experience

All of the above experiences include sound. The first part of the kit was completed.

For the second part of it, associated to acts and consequences, the information needed in order to proceed was gathered after two weeks.

At school Jessica potentially gets assigned green, yellow or red thoughts throughout the day at the end of each period. At the end of the day if all are green she gets an overall green thought for that day. If during the day she gets one or more yellow, she gets an overall yellow that day and if one or more are red she gets an overall red for the day. In order to obtain her chosen reward (I.e. Go to a movie) she must get a green for each day for a certain number of days in a row, in this case 10 days in a row.

Green thoughts are for different aspect such us: helping, staying on task, using proper language, cooperating, taking initiative, being a leader, trying your best, being kind, being independent.

Yellow thoughts are for bad language, not following routine and getting off task, yelling, being rude, being mean, and not being cooperative.

Red thoughts are for getting aggressive.

For this part of the project reinforcement will be included as a reward for correct answers and behaviours. Also when she gets a red thought she will get a penalty; the purpose is to make her understand that bad behaviours have consequences.

At school if she gets a yellow or red thought she will loose the reward.

Same for home.

For Jessica, rewards are things like: a meal at a restaurant, or snack/drink out (McDonalds, Starbucks or Tim Hortons), a movie, going out for ice cream, a sleepover, baking, an outing with a friend, a new CD, computer time or iPad time.

At home a yellow will be for crying, yelling, saying nasty things or swearing. She would get a warning and if she doesn't stop the consequence will be spending time in her room.

For aggression/red it's an automatic consequence of an hour in her room.

Tamara, Jessica's mom, usually start saying 1/2 hr. must be spent in room. She adds time on in 15 min increments if the negative behaviours don't stop or if she doesn't walk to her room.

Taking this into account, the flashcards will show rewards and/or consequences according to Jessica's behaviour. The rewards will be maintained as a secret. For example if the reward is going for an ice cream the flashcard will only show "reward # 1" (and not the image of an ice cream). When she uses the iPad camera the image of an ice cream will show up and a voice will describe what she just won. In this way, without knowing which reward is on each

flashcard, there will be a little guessing game and fun in the activity. This applies for the green thoughts.

The flashcards for this activity are as follow:

Figure 40 Reward flashcards

As it was mentioned before, the flashcards wont be showing the image of rewards. Here it was necessary to work with different font styles because the AR software wasn't detecting the markers because of their similitude.

This is how the experience will look like (every flashcard will explain what is the reward about using sound):

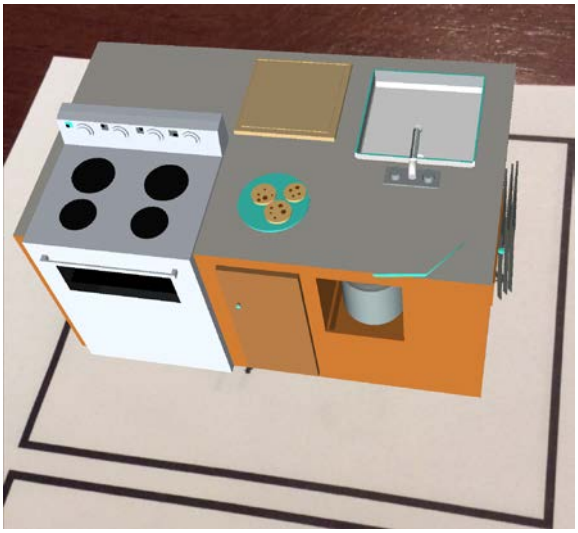

Figure 41 Reward # 1 Baking

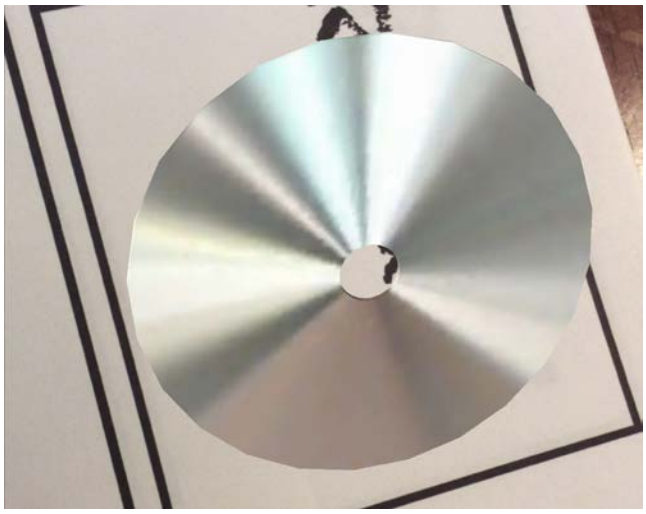

Figure 42 Reward #2 New CD

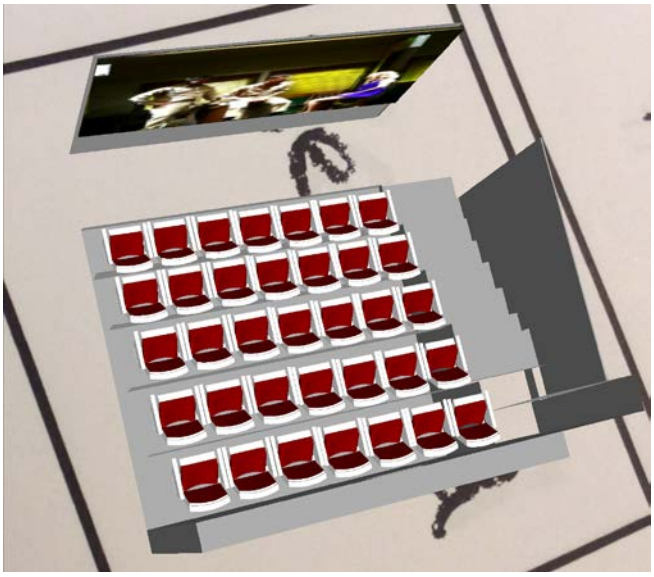

Figure 43 Reward #3 Going to a movie

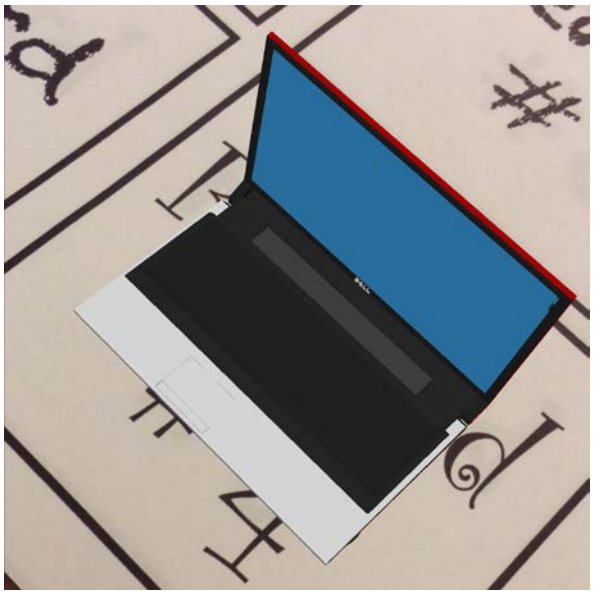

Figure 44 Reward #4 Computer time

Figure 45 Reward #5 Going out for ice cream

Figure 46 Reward #6 iPad time

Figure 47 Reward #7 Snack/drink at Mc Donalds

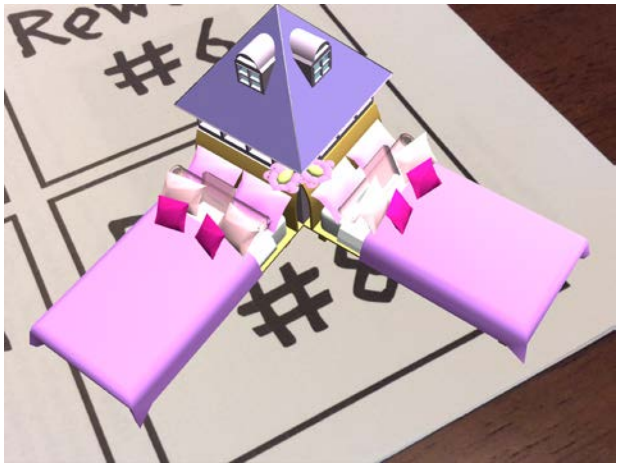

Figure 48 Reward #8 Sleepover

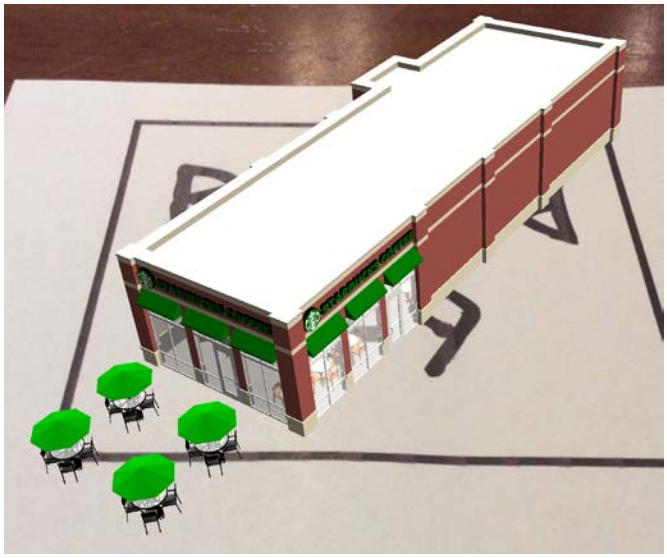

Figure 49 Reward #9 Snack/ Drink at Starbucks

The rewards activity kit was ready for its first user testing during our third user testing meeting.

6.3.2.5 Third Session

27th March. During this session Jessica and her parents interacted with the Rewards activity kit. At the beginning of the meeting we talked about the activity itself, how she can win or loose points and finally if she will get a reward or a penalty. When all the participants were on the same page, I showed the flashcards and they tried it by their own. They already knew how the iPad and the flashcards works together so there was no need of going deeper in this.

Their reaction was the one I was expected. They liked the idea of not having the image of the reward on the flashcard in order to make this part of the project more of a fun guessing game. They were satisfied with the 3D modelling but the flashcards suffered some changes after the user testing. The first change was the size of it; during the therapies is it easy to manipulate the flashcards and the child at the same time but when you add another element, such us the iPad, this activity became complicated. Jessica's parent asked for a smaller size for the flashcards. Another change was the patterns of the flashcards. During the first user testing round having only black and white flashcards and similar font style, I discovered that the AG tool was having trouble differentiating the different markers. In order to fix did the flashcards now have different colours, font style and shapes on it.

After these changes the reward experience was completed. The family also wanted to start working on the penalty part of this experience but because of time restrains this wasn't possible.

Behaviour and consequences flashcards:

Figure 50 Reward No. 1

Figure 51 Reward No. 2

Figure 52 Reward No. 3

Figure 53 Reward No. 4

Figure 54 Reward No. 5

Figure 55 Reward No. 6

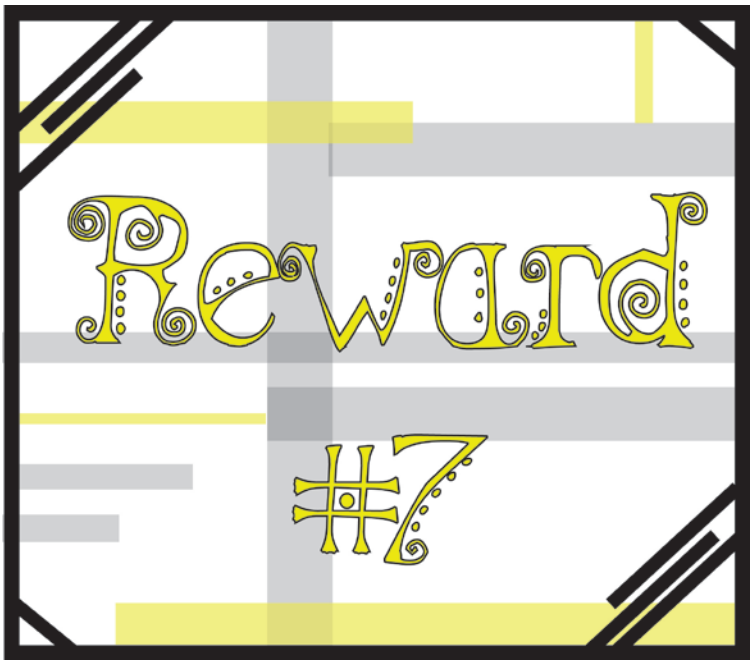

Figure 56 Reward No. 7

Figure 57 Reward No.8

Figure 58 Reward No. 9

7 Conclusions

Lets take a look again at the research question of the project:

How can an interactive digital tool help children with autism spectrum disorder (ASD) facilitate and improve their daily learning and activities?

After a year of working on this research project, I can conclude that technology can be a great tool to help children with ASD to achieve different goals and improve in different tasks. Technology opens the door to the use of new techniques during the therapy and even for daily life activities outside of the therapy space. Children with autism enjoy spending time using technological devices and we must take advantage of this engagement in order to create products that will beneficiate them and their families.

There were some factors that delayed the prototype evolution and I must say that I feel I did not address its development the way I was expecting to do it. A big challenge was finding a child participant with ASD. Although I have a great and interesting prototype, with more time and interaction with the child the prototype could had achieve a better development.

The main objective of the project was to create a helpful and technological tool for children with autism. From my perspective I achieved this goal, but with more time the results could have been greater. A goal that was completely achieved was working with all the users of the project. This experience and

interaction gave significant insights for the development of the tool.

Augmented Reality proved to be an interesting and engaging tool not only for Jessica but her parents and therapist too. The users liked the fact of having different elements working together in just one device (sound, 3D modelling, video…) and showed interest in keep practicing and using the different prototypes they had the chance to interact with. Having the iPad as part of the project was a good choice because children with autism enjoy playing and learning with it. In some institutions is already been use as part of the therapy. For Jessica the iPad represents learning and fun at the same time.

The creative process of this project was focused on Jessica, just one child. The advantage of this decision was the close interaction with her and her family. Working with more children at the same time could lead to not having this close relationship and feedback from the user. Because every child with autism is different, every small detail must be taken into account. Understanding autism can be a hard task; working with just one child was the perfect opportunity to get a better understanding of this condition when you have never had a real interaction with someone with ASD and its world.

Personally, I don't find any disadvantage of having only a child in the project because this experience was the first step into the autism world. This encounter and experience was something necessary to start working for more children in the

future.

7. 1 Challenges

A World of Images was a fun and interesting experience, but it wasn't always an easy path; along it were many challenges that I had to face in order to succeed.

According to my experience in the development of this project, I would say that the harder part of it was to get in contact with a child with autism. At the beginning of the process I was worried about the technological improvement and whether I would manage to make my idea tangible and real, but on my way I found people that already knew what I needed and taught me. Some aspects I learned myself, this requires more time, but it’s a great feeling to see how you can improve by your own. But, going back to the child with autism, if you don’t have contacts, if you don’t know someone that could probably know someone with a family member with autism, this task could become a nightmare, and for me it was becoming a really bad one. I tried contacting several autism organizations, offering myself as a volunteer; even my thesis supervisor helped me with his contacts but the future was looking bad. I was panicking! I felt for several months that my thesis was stuck in there…I needed a child in order to continue with the evolution of my prototype and my thesis. Finally one of my thesis supervisor contacts and one of friend of mine helped me out. I had found a child to continue with the process!

I was ready to start the user testing and I was really excited about it, but here is where another issue appeared. I didn't have the REB (ethics) approval yet. Without this I couldn't approach the kid or their family members. This process was really long, starting with the documents getting lost and concluding the process after a lot of changes on the formats. I started the ethics approval in September of 2014 and I got the approval until late January of 2015.

So finally I had my ethics approval and a child, I was ready for the user testing. But here comes my 3rd problem. I was ready to go but the 4d Daqri studio started to do a general maintenance of the software. What's the meaning of this? All of my AR experiences stop working so I didn't have anything to show to the user. Solution? Wait until they finish with the maintenance and upload of the software. This took 2 weeks.

When the Daqri software was ready to go, I was also ready to go: user-testing time.

7.2 What I learned

1. There are different type of thinkers, we all don't think and see the world in the same way.
2. Intelligence of children or people with autism is misunderstood.
3. In the specific case of Jessica, working with the iPad is something fun. The iPad is also a reward when she has a good behaviour. This shows that

this device was a good choice for the development of the project's idea.

4. We want to have an inclusive world, some of us want to work for an inclusive world; but sometimes, maybe because people are scared of someone hurting their children, they are distancing the children from the world.
5. Just because someone has autism it doesn't mean that all of them are going to react or act in the same way, each of us is a special and different human being. (Just like all of us)
6. It's pretty different to work for cognitive disabilities instead of physical disabilities. For a physical disability you can design something that will work for all the people suffering that specific condition, but it wont be the same case for a person with a cognitive disability. A cognitive disability needs a more deeper user-centered design method.
7. Without a Wi-Fi signal the project wont work

7.3 Future Steps

As it was mentioned before the users were found in a very late stage of the creative process, so the first future step of this project will be to do a user testing related to the rewards and penalty activity. After the user test the project would suffer some changes.

The iPad was selected because it is already been used in the therapy and

children are used to it. I would also like to do some user testing with other type of technological devices or exploring even more the advantages of AR. At one point in the process I thought about wearable technology like the Google glasses. This would be an interesting path, but children with autism are highly sensitive to body contact making this idea inappropriate.

I like to think that my project has a great future; I think it is a great opportunity to show it to autism institutions, do some industry partnerships and continue working with children with autism to make it even better and at some point have it on the market. This project with the right industry partnership can become something big in the autism world.

The project could be a sustainable tool for a long-term approach having a design team that will work together with an autistic institution. This institution, after doing the necessary exams and tests with each child (as they actually do when they receive a new child), can work together with the design team in order to create the best therapy approach according to each child's needs. The therapists would give the design team the insights and feedback for the creation of the digital tool. Currently, the therapy evolves according to the improvement of the child and the tool that I am proposing can evolve too. This is the advantage of the creation of a digital tool that can be adapted to each child needs. As the regular therapy evolves the new digital tool for the therapy will so also.

I would also like to show it in Colombia, where I did have some contacts

but because of the distance I wasn't able to share the project with them.

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Appendix

Appendix A: Therapist interview

- **What would you say it is the most difficult part of the therapy?**

  Definitely social skills. For example in some cases, mostly of the cases, they don't even respond to their own names. If you ask them how are they feeling or how is their day going, they won't answer anything or they will give the same answer to all of the questions. They don't understand emotions or facial expressions, if one of them is having a sad expression and you approach to ask what is happening, he won't understand what you are trying to ask, he won't understand what is the meaning of being sad. This also works in the opposite way, if someone is sad the kid won't be able to understand others person feelings.

- **What can you say about the relationship between images and therapy?**

  They are what we call visual learners and thinkers. A therapy involves many images. For example, they have pictures schedules to help them learn different activities such us brush their teeth or take a shower. All of these with pictures that shows the activities step by step.

- **How are the therapies?**

  The therapies are one to one. We teach them different topics, for example numbers or reading, but we are really focused on being independent

(getting dress, using the toilet…) In all the different topics we use step by step learning. For example when we teach them how to get dress we start with the t-shirt, when they have learned how to put on the t-shirt we continue with the pants, and when they have learned the pants we continue with the socks. With them it is always a repetitive process. And if they don't learn the first step you can't move on to the next one. It is one thing at a time and we mostly of the time work in isolation. The children with high functioning levels sometimes work together.

- **Do you use any technological tool or device during the therapies?**

  In this moment we are using iPads. We use different apps to teach them for example the opposites, matching, capital letters, and things like that. We also use the iPad with children that can't vocalize. We have some pictures on the iPad, let's take as an example a picture of a bottle of milk or a picture of potato chips; the child clicks on the potato chips image and he will hear "I want potato chips". The voice that comes out of the iPad is actually our own voice, the voice of the therapist; we recorded the meaning of each picture. This is what a child that can't speak uses to communicate.

- **What would happen if a child wants something that is not in those images?**

  When a child is new in the therapy we start with something called Reinforcement Assessment. Here we show the children a lot of different

images of different things in order to see what they like and what motivates them. Knowing this we can add the image and voice to the iPad that the child normally uses.

- **What do they do for fun?**

  They really like technology. IPads, computers or TV. They don't play with toys or they don't go outside to play, actually not even children without the syndrome play outside anymore, all of them are at their places playing with technological devices.

At this point of the interview, and of the project development itself, I didn't have an actual prototype or something tangible to show to the therapist, but as it was mentioned before I knew that I was going to develop an AR tool. After the first insights about how images are an important part of the therapy I thought it could be interesting to have an AR kit with different activities on it explained by the use of images. In other words ***"A World of Images".*** I explained this idea to the therapist in order to gather some feedback and to know if an AR tool that works with images was a good approach for children with autism. After I explain the project's idea, the interview continued as follow:

- **What do you think about the project? What would you add or change?**

I think it is interesting and a good idea. I think some of the kits could be more challenging in order to have kits for high and low functional children. I like the idea of being a kit because you can take it with you and keep practicing wherever you go.

For example if you have a daily activities part, you can create all of the kits for low and high functional level because this is something that we teach no matter the level of autism. You can work with making the bed, set the table, loading the dishwasher, take a shower, using the toilet, teeth brushing, get dress. For fun activities you can use play with the iPad, turn on the TV, play a movie on the DVD player, how to play music on the radio. For therapy or education you can use animals sounds, numbers, colours, facial expressions or community helpers.

Appendix B: Family interview

- **Do you know someone with autistic spectrum disorder?**

  Yes __X__ No ____

- **According to your own experience, what do you know about the ASD?**

  Wide range of abilities within the ASD spectrum

- **According to your own experience, what would you say is the most complex task for someone with ASD?**

  Communication

- **Is the person with ASD that you know attending therapy?**

  Yes

- **How is the therapy? (What are the main topics they learn, how do they learn it, what tools do they used?)**

  Speech and OT. Also learning life skills at home and school, work placement skills ar school. Various tools including visuals, some use of iPad, repetitive teaching.

- **Do you think people with ASD learn easily with images and pictures? Please explain your answer**

  They don't learn easily at all but visual AND hands on learning is most efficient

- **Are there any technological devices being used during the therapy?**

  Yes

- **Does your child seem to enjoy using technological devices? (Tablets, smartphones…)**

  Yes

- **If you knew there is a new tool for kids with ASD that combines music, video, sounds and 3D modelling, would you be interested in**

trying it as a complementary part of the actual therapy? Please explain your answer

Yes