Investigating the Use of Collaborative Technology in Autism Therapy

By: Georgios Ardamerinos, Hope Shevchuk, and Julia Smith

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Investigating the Use of Collaborative Technology in Autism Therapy

Product development and Market Analysis for Callaghan Innovation in New Zealand

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Chapter 1: Introduction

Autism Spectrum Disorder (ASD) is a developmental disorder that affects a large percentage of the population worldwide, affecting an average of 1 in 68 individuals (Autism Speaks, 2015). The disorders that fall within the spectrum are accompanied by a large range of symptoms and challenges that researchers are currently addressing. Some of these symptoms include an inability to concentrate, learn in a traditional school setting, and control repetitive or compulsive behaviors. Because ASD does not have a specific cause, there are a variety of options for treatment and therapies to address the disorder. The newest forms of treatment for ASD include various types of assistive learning technologies, including games and software that utilize traditional therapies for the disability.

The area of focus for this project is New Zealand, where autism is slightly less common, affecting 1 in 100 individuals (AutismNZ, 2015). However, ASD is still a definite concern and consequently, there are researchers currently developing possible assistive technology for the use in the ASD community. One such company is our project sponsor, Callaghan Innovation. A research team at this company is in the process of developing and testing an assistive learning tool in the form of collaborative touch screen game for children with ASD called “Talk-to-Me” (King, 2015). The research team hopes that Callaghan will release this game to the New Zealand market and eventually, the international market. However, Callaghan has yet to determine if the product will meet the needs of the ASD community in New Zealand and moreover, whether or not there is a niche in the international market for this product in order for it to be successful.

The major goal of this project is to assist Callaghan Innovation in producing and marketing their collaborative learning technology game that meets the need of the stakeholders in this community. In order to achieve this goal, this project will identify and analyze data regarding

current products, consumer needs, and Callaghan's marketing process collected by means of literature review and stakeholder interviews. A literature review is necessary to find the current technologies that researchers and other companies tested and developed to determine the qualifications of a successful collaborative learning tool. It is also necessary to conduct stakeholder interviews in order to fully comprehend the needs of the consumers. The stakeholders that we aim to contact are special education teachers, therapists, parents of autistic children, and members of the Callaghan marketing department. With this information on both the technologies and market for these technologies, we hope to determine the feasibility of commercializing Callaghan's product successfully and provide recommendations on the best approach to achieve this goal.

Chapter 2: Background

This chapter provides an overview of the use of technology in the development of social skills for children with Autism Spectrum Disorder and the market for such technologies. The mission of Callaghan Innovation, the sponsor of this project, is to help New Zealand businesses succeed through technology (Callaghan Innovation, 2015). They are a New Zealand government funded agency that works with other partners including the New Zealand Trade and Enterprise (NZTE) to provide "comprehensive and integrated solutions for New Zealand businesses" (Callaghan Innovation, 2015). Callaghan Innovation provides access to experts, technology and product development, innovation skills, business collaborations and grants for research and development purposes. Callaghan Innovation asked us to investigate the market, the need for and the use of Information and Communications Technologies (ICT) as a social skills training tool in special education, specifically in autism. Their current research involves the use of collaborative games in technology. They have developed their own collaborative learning tool, Talk-to-Me, which will be further discussed in this chapter. This chapter will review autism in the New Zealand community and other collaborative technologies similar to Talk-to-Me.

2.1. Autism Spectrum Disorder (ASD)

This section clarifies the complex group of brain development disorders known as Autism Spectrum Disorder, its symptoms, and its current treatments. This information will provide a solid understanding of the disorder as a whole.

2.1.1. Symptoms and Key Facts of ASD

Autism Spectrum Disorder (ASD) is a developmental disorder that affects a great number of people, both children and adults, worldwide. Currently, statistics show that 1 in 68 children will

be born with some level of ASD (Autism Speaks, 2015). Although ASD is more common in boys, showing statistics of about 1 in 42, it still affects girls with diagnosis rates of 1 in 189. This range of disabilities is the source of a great number of challenges that children with ASD face every day and researchers are continuing to search for better mechanisms to alleviate them.

Children with ASD, along with their parents, experience a multitude of difficulties in day to day life that other families do not have to worry about. Medical professionals classify ASD as a developmental disorder that has varying levels of disabilities, giving rise to the classification of the disorder as a spectrum. Common symptoms and effects of ASD are various kinds of behavioral and emotional problems. Autism is most often associated with an inability to engage eye contact or hold a conversation, as well as repetitive and sometimes obsessive behaviors. Children with ASD have trouble communicating, interacting, identifying emotions, engaging their attention, and adapting to new situations (CDC, 2015c).

Additionally, autistic children are often unable to respond correctly to social cues or other people's emotions (Prevention, 2015). Since these children are unable to recognize that body language portrays feelings and expressions, other people tend to feel that the children's responses are rude or inappropriate. Autism Spectrum Disorder is also known as the "Wrong Planet Syndrome" (Marwecki, 2013). Autistic children typically see themselves as normal and their surroundings unusual as if they are living on the "wrong planet" which makes engaging in social interaction difficult.

Symptoms usually onset early in life and children generally display these symptoms within the first two years, leading to the need for early intervention in order to treat the effects of the disability so that the child is able to function as normally as possible. Given how much this range

of symptoms can affect the child's life and development, taking initiative to get early treatment is vital in the process (NIH, 2015).

Tailoring to the needs of each child is difficult, especially when there are so many different ways in which autistic children learn. According to Hirstwood Training, there are seven main learning styles that are most effective in autistic children (Hirstwood, 2014). If a child is a verbal or linguistic learner, they will learn best with the use of words, written and spoken. Some children are logically or mathematically driven and they pay attention to patterns and work well with numbers. Musical children use their auditory sense to process sound and spoken words. Visual learners benefit from images and color distinction. Kinesthetic learners improve learning through movement and mimicking actions. It is important to acknowledge that learning is dynamic and no child experiences one singular learning style; children often change preference over time.

2.1.2. Treatments for Children with Autism

There are a number of methods for the treatment of children with autism. Most of these therapies focus on identifying problem behaviors and using various techniques in order to address the problem. The newer and more advanced assistive learning technologies that researchers are currently developing use these methods.

Applied Behavioral Analysis (ABA) is one of the most common treatments for children with ASD. This method is an in depth and lengthy process that requires ongoing assessment of the child's progress and constant alterations to the proposed teaching plan. The basis of ABA is analyzing the child's various behaviors, both normal and ASD influenced, and determining which behaviors should be encouraged or discouraged. Teaching the correct behavior is also involved so that the child can learn to replace the poor behavior with better (Autism Speaks, 2015).

The effectiveness of ABA also depends on differential reinforcement. Differential reinforcement refers to positive and negative reinforcement of varying intensity for various kinds of behavior displayed. These reinforcement methods do not include physical punishment (Morris, 2015).

A professionally trained behavior analyst or therapist is in charge of the child's therapy but works with the family to set reasonable goals for the child's progress and to teach the family techniques for responding to certain situations. The therapist designs and constantly modifies a personalized curriculum specific to the needs of a child (Autism Speaks, 2015).

There are a number of teaching strategies involved with ABA which are meant to discourage bad behaviors and reward good behaviors. One of the first methods is a combination of task analysis and chaining. Task analysis is the breakdown of complicated tasks into smaller, more manageable actions. Chaining is the further separation of the smaller actions into their vital components so that the child is able to apply them one step at a time and slowly combine all the actions into one, to complete an entire task. For example, for a child to make a sandwich, the therapist could break it down into retrieving the plate and knife, getting the bread and peanut butter, spreading the peanut butter on the bread, and finally putting the pieces together. The smaller steps are often easier to handle for the child to complete the task (Morris, 2015).

Task analysis and chaining are also intertwined with another teaching strategy, prompting. The therapist uses various prompts to encourage the correct behavior or response. This prompting could be telling the child to pick up a block and put it away or suggesting a more in depth response to a question asked (Morris, 2015). Since children with ASD are often unwilling to respond to conversation or respond as succinctly as possible, this method allows them to expand their answers

and conduct a better conversation. It also allows for giving directions in regards to any task that the child is attempting to complete.

However, the therapist should not use prompting all the time with the child because the end goal is fading. Fading refers to the process of slowly weaning the child off of task prompts. As the child advances, he/she is able to complete the tasks correctly and without guidance for the fading to be complete. The goal is that the child will recognize a situation and know the proper response without assistance, but the fading process allows guidance where it is needed (Morris, 2015).

The last step in the process is generalization. This step is one of the most vital and also most difficult in which to succeed. Generalization is ensuring that the child can apply the lessons learned to more than one specific circumstance. It requires turning a skill learned in therapy into general knowledge that the child can apply outside of therapy. This application would allow the child to know how to respond to a similar situation in their lives without the use of prompting (Morris, 2015).

One disadvantage of ABA is that the therapy takes 25-40 hours per week for 1-3 years. In other words, an individual with ASD using this method may need to exercise five hours every day for three years to complete the program. It also requires someone to work with the ASD individual for this amount of time every day; this is a starting point where learning software can help and reduce the cost of the treatment.

2.1.3. Other Disabilities with Similar Characteristics to ASD

There are many other conditions and disabilities that produce similar signs and symptoms to children with Autism Spectrum Disorders (ASD). Since ASD is a spectrum, it covers many

levels of severity in the autism disorders. Three main categories on the spectrum are low functioning autism (LFA), moderate functioning autism (MFA), and high functioning autism (HFA) (Marwecki, 2013). Asperger syndrome is a diagnosable disorder that exists on the spectrum that contains characteristics similar to HFA (Marwecki, 2013). Other disorders that are not specifically defined on the spectrum can have similar symptoms to ASD. These symptoms categorized by impairments in areas of communication, language and social interaction are called Pervasive Developmental Disorders (PDD) (Silva, 2014). A more in depth discussion about some specific disorders that relate to symptoms similar to ASD and PDD can be found in Appendix A.

2.2. Rights and Resources of Special Education Students in NZ

The Education Act of 1989 legally holds the rights of all New Zealand students (Ministry of Education, 2015a). This document, administered by the Ministry of Education, provides the legal framework for the educational system of New Zealand. In regards to children with special needs, it states that they have equal rights to enroll in primary education, secondary education and partnership schools compared to “normal” students (Ministry of Education, 2015a).

The New Zealand Disability Strategy created by the Office for Disability Issues also holds New Zealand schools to standards (MSD, 2009). This strategy provides a framework to help the government remove barriers between society and the disabled. It uses five themes that will support disabilities in the community: public awareness, resources, support services, incorporation, and understanding (MSD, 2009).

The Ministry has also pushed to increase the use of inclusive education strategies into schools; the Education Act of 1989 founded this idea (Ministry of Education, 2015c). Inclusive education focuses on engaging students through the use of flexible practices that adapt to the needs of the students (Ministry of Education, 2015b). The use of this method ensures that in daily school

practices, all students and teachers recognize all identities, languages, cultures, abilities and talents (Ministry of Education, 2015b). School systems in New Zealand are starting to incorporate inclusive education and this method is working its way into the special education branch creating more individualized approaches to learning.

The Ministry of Education is investigating and instigating assistive technology as a resource to assist special education children. Assistive technology is any form of technology that helps a child with special needs to perform tasks that he/she would otherwise be unable to perform entirely on his/her own. However, since these more advanced technologies are often expensive, the Ministry requires that children with a high level of need demonstrate eligibility for the use of this technology. The children must also be currently enrolled in school and there must be proof that the current technologies in the school are insufficient for the child's learning in order to receive this technology (Ministry of Education, 2015c)

The department also recommends that the parents initiate a learning assessment to discover more about the child's disability and the obstacles that stand in the way of learning. Given the costly nature of the assistive learning technologies, the Ministry requests that they should take less drastic steps first to determine if cheaper and more accessible tools and technology are available; these modifications should exist in both the child's curriculum and/or learning environment. If the less advanced technologies are not adequate to overcome the learning disability, the Ministry is then willing to begin supplying the more advanced assistive tools (Ministry of Education, 2015c). In order to determine how much Ministry involvement is required, there are three levels of need: low, moderate, and high. The Ministry is generally more involved with moderate and high level need children and it will bring specialists or therapists into the school environment to assist the teacher with the children if deemed necessary (Ministry of Education, 2015c).

Though the Ministry is reluctant to employ these technologies unless necessary, they provide additional resources that are very helpful in the educational advancements of special needs children. There are many sources of support for this type of technology including important information about the technology and how it works as well as news about the release of newer technologies in the future. There are specialists who are able to advise the best type of technologies for each situation. They can determine the child's main area of need and recommend the applicable technology for a specific child (Ministry of Education, 2015c).

The Ministry of Education also has a number of employees that facilitate the process of using this technology and adapting the child to this new learning environment. There are field staff members that work with the schools to integrate the technology, either one-on-one with the student or with a therapist to determine the best treatments and therapies. Additionally, there are district technology coordinators who are responsible for determining the need of the child and the type of technology best suited for their situation and need. Finally, the Center for Assistive Technology is a helpful resource for finding information about various types of assistive technology and news about the newest types of technology that exist today (Ministry of Education, 2015c).

In the current New Zealand school system, there are many options and methods of support and treatment for families with children with ASD or other such disabilities. The Ministry of Education stresses the importance of early intervention and treatment to ensure that caregivers monitor the disability so that is does not severely inhibit the child's life and development. The level of Ministry involvement varies depending on the situation but the Ministry is still dedicated to supporting children and their families during school (Ministry of Education, 2015c).

There is no additional cost to the families of the children with ASD because the government funds all fees and expenses for these resources in school. Though it provides an extensive support network, the Ministry advises all families with affected children to build a support group of their own because of the difficulties that can sometimes be faced during the education process. The support of friends and relatives can assist with difficult and trying situations while also ensuring that the child's company is not limited to his or her therapist (Ministry of Education, 2015c).

2.3. Collaborative Approaches in Treating Children with Disabilities

This section investigates the collaborative learning techniques, games, and tools currently used for children with ASD. This analysis describes the features of existing games in the market to identify effective characteristics.

2.3.1. Collaborative Learning Techniques

Collaborative learning is a technique utilized in schools and therapies in order to maximize the development of social skills and behaviors in children. These techniques are also important in the different kinds of learning technologies because they have the ability to teach a number of crucial skills.

Collaborative learning is an important aspect of most educational systems because of its many positive outcomes. Collaborative learning, also referred to as cooperative learning, is designed to maximize the number of skills a child can develop during a lesson through working with at least one other student on the task at hand (Cornell University, 2015.) The structure of collaborative teaching is a simple three step process: initiate, time, and conclude. The first step is initiating the task or problem. Second, the teacher must provide adequate time for the students to complete the task to the best of their abilities. Finally, after the task is completed, the various

groups should reconvene and share the results of the discussion or problem solving session, while asking and answering questions (Cornell University, 2015).

This method of teaching is helpful for a number of reasons. Collaborative learning first and foremost is assistive in developing social skills. Since the students must work together and communicate in order to succeed in their task, this strategy forces them to interact for an extended period of time. Group work is also conducive to gaining and appreciating the perspectives of the other students in the group. Collaborative work, by necessity, facilitates discussion and independence, while also encouraging participation of all individuals involved. Finally, this type of learning situation mimics those found in real life, as many jobs and later forms of education are decidedly group oriented (Cornell University, 2015).

Collaborative learning has an almost unlimited number of applications depending on the teaching situation. In a school setting, one common example is “think-pair-share.” First, the teacher poses some question or discussion point that requires some amount of extensive thought and each student has to create an individual response. Then, the student pairs up with another student to share thoughts and perspectives. When the two person discussion is complete, the pairs gather in order to share their findings and discuss different answers formulated by other groups. This enables the students to think for themselves while also needing to communicate with others by properly explaining their own ideas. They are able to understand and appreciate a number of different perspectives and are more likely to retain information given the interactive format of the discussion (Cornell University, 2015).

2.3.2. Collaborative Learning Games

In current learning environments, there are a number of collaborative board games on the market that are specifically designed to encourage the children to interact and work together

towards the same goal. Rather than playing against each other, the children take turns in trying to complete the final task of the game. There are a number of these board games that have been created especially for children with ASD in order to teach them these valuable skills.

Stone Soup (seen in Figure 2.1 below) is a game that is both collaborative and instructive. This matching game is specially designed for children who are either language or reading delayed and are therefore more visual. It is a collaborative game in which the team members work together to make decisions and decide on the correct move. Because of the game's combination of language and visual cues, children of all abilities are able to contribute equally and feel like they are an important part of the game (National Autism Resources, 2015).

Figure 2.1. Stone Soup, a collaborative children's board game (National Autism Resources, 2015)

Hoot Owl Hoot (see in Figure 2.2 below) is another example of a fun collaborative tool that teaches valuable skills to children with ASD. It teaches the children playing about the importance of turn taking and working together. In the game, the players are on the same team and work towards the end goal of "waking up the owl" before the sun rises in the game. Additionally,

the game has a colorful board and pieces that are ideal for children with autism or language delays (National Autism Resources, 2015).

Figure 2.2. Hoot Owl Hoot, a collaborative children's board game (National Autism Resources, 2015)

2.3.3. Collaborative Technology Tools and Autism

Individuals with ASD often find working with computers and electronics less intimidating for many reasons. They have an easier time visually focusing on material illustrated on a computer monitor (Ozonoff, 1995). In addition, many children like software programs because of their predictability, the repetition of the activity, and the engaging animation (Herskowitz, 2003). Educational software, which belongs to the category of serious games, refers to computer programs that target certain skills. Such software is more effective than traditional methods of learning and children with ASD find it more motivating and less stressful due to the attractive colors and the ease of use that technology provides (Daymut, 2002).

Technology creates a promising tool to establish a collaborative environment. Collaborative games with computers or any digital setting elicit face-to-face communication that

would normally not occur and often result in higher motivation and involvement (Marwecki, 2013).

Researchers have investigated the use of different forms of technology in this field. Computers, tablets, and other unique electronics are products in development to encourage collaboration. Computers have the ability to download different software which can be simple games or versions of collaborative virtual environments (CVE's). CVEs are virtual environments which typically involve a child playing through an avatar in computer generated situations (Parsons, 2011). What makes these collaborative is that they involve interaction with other avatars that can either be played by another student or a teacher/caregiver/therapist to initiate appropriate behaviors in virtual setting that is comparable to real life (Parsons, 2011). Some of these environments, like *Block Challenge* (seen in Appendix B), involve headsets and visual goggles that immerse the player into a more realistic environment (Parsons, 2011). Similarly, another form of a CVE is through a "blue room"; a blue room is a room in which projections of environments establish a situation that allows the child to experience the program more naturally (Parsons, 2011).

The University of Birmingham has initiated a project funded by the European Commission called COSPATIAL (Millen, 2010). COSPATIAL stands for Communication and Social Participation: Collaborative Technologies for Interaction and Learning (FBK, 2008). A few specific games from this project are discussed in section 2.5. This project advocated for the use of CVEs as well as Shared Active Surfaces (SAS) (FBK, 2008). SASs are a wide category of interactive surfaces that respond to user input including computers and tablets/touchscreens.

These surfaces are also classified under tangible user interfaces (TUIs) (Silva, 2014). Compared to graphical user interfaces (GUIs) which use Windows, Icons, Menus, and Pointers

(WIMP), TUIs are more interactive in that they involve response to touch (Silva 2014). An example of a TUI is the DiamondTouch, a multi-user touch technology, which is a common tool in collaborative games (Dietz, 2001).

2.4. Principles of Effective Collaborative Learning

This section will compare and evaluate the most effective principles that exist in games that use technology to encourage collaboration. In our research thus far, we have found that the most common platform for this type of product is touch screen technology so we have limited our focus to this area. There are many common techniques and strategies used across the existing games. A list of all collaborative technology games that we have found thus far can be seen in Appendix A.

A major challenge faced using games in autism therapy is keeping children engaged. There are some critical features that make these games successful in directing attention. It is important that the objective of the game is very clearly stated and easy to follow (Marwecki, 2013) but complex enough to stimulate cognitive curiosity, which is the desire to learn more in reference to the game (Wang, 2009). The child will have more enthusiasm towards completing a task through a goal that triggers a personal connection (Wang, 2009). Most of the games allow for multiple solutions which encourage the children to think creatively and provide more opportunities for success (Wang, 2009). Similarly, more effective and desirable games are the ones that have the ability to change their difficulty in order to tailor to the individual skill level (Wang, 2009). Feedback mechanisms are also important to keep children engaged and those used are typically visual and auditory (Marwecki, 2013).

Two main techniques to use collaboration in these games are enforced collaboration (EFC) and encouraged collaboration (ECC) (Marwecki, 2013). Enforced collaboration means that a task must be completed by multiple users simultaneously in order to accomplish the given task. Encouraged collaboration means that the game suggests that cooperation will be more successful with user interaction, but does not require it. *Invasion of the Wrong Planet* is a game in which children control a spaceship and have to shoot invaders to beat a high score (Marwecki, 2013). This game uses ECC by rewarding players with more points when they attack an invader together but does not require it to complete the game.

There are three main collaborative actions that result from cooperation. These include joint performance; performing an action together, sharing; an exchange of information and resources, and mutual planning; coordinating actions and resources (Giusti, 2011).

Collaborative techniques can be categorized under specific collaborative patterns. According to Giusti (2011), methods used in these games are "choosing together" and "constraints on objects" which researchers associate with joint-performance. "Different role" and "ownership" are other methods which mostly relate to mutual planning. Choosing together is a method that requires two or more players to pick something together either on screen or in the approach to the game. An example of a constraint on an object is in *The Collaborative Puzzle Game;* in order to move any puzzle piece, two or more players must move the piece simultaneously (Battocchi, 2009). The different role method assigns each player a unique responsibility in the game which requires the users to communicate. In the case of *PAR,* one child is responsible for packing clothing items into boxes and the other is responsible for shipping the boxes (Silva, 2014). Ownership is similar to different role, but it is specific to a particular object; so each player has complete control over one object or avatar.

Silva et. al. (2014) identifies four sharing patterns in collaborative games. Passive sharing is an action, response pattern that does not require an exchange of information to complete the task, but does enforce reliability on user actions. In the game *PAR*, one child has to place an item in a box and the second player has to put the filled boxes in a cart (Silva, 2014). This collaboration is passive sharing because no interaction is needed to complete the task, but one user must wait for the other to finish their task before they proceed. Active sharing is a method where the exchange of information is necessary. *PAR* uses active sharing by requiring the first user to inform the second user of the item to place in the box. Once the second user requests and receives this information, he is able to complete the task and move onto the next activity. Active sharing and joint-performance is a combination of the two methods. So in the case of *PAR*, the active sharing activity previously discussed has an additional task which includes the user who then has to open a box for the other user to place the necessary object in the box requiring the exchange of information and a joint activity. The last method of sharing is unrestricted interaction pattern. As the name implies, the game requires no exchange of information or joint action, so each user is free to accomplish the task individually or collaboratively.

2.5. Case Studies Involving Autism Therapy Games

This section discusses a variety of collaborative software and tools for children with ASD that researchers have tested and published. By analyzing the different features, results and methods implemented in these games we will be able to provide recommendations concerning our sponsor's product.

2.5.1. The Collaborative Puzzle Game

The Collaborative Puzzle Game (CPG) is a computer version of a jigsaw puzzle that is implemented on the DiamondTouch interactive table studied by Battocchi et al. (2009). In this game, the participants recreate the original picture by putting together puzzle pieces on an interactive screen. The screen display consists of three main areas, the solution area, where the participant should make the puzzle, an open area to move and handle the pieces and the original image area (Seen in Figure 2.3). The 32" tablet, designed by Mitsubishi Electric's Research Laboratories, has the ability to recognize up to four users simultaneously. One game setting on the software requires both users (two children or one child and a caregiver) to move the puzzle pieces together; both users must grab, drag, and release the puzzle on the screen.

This game exhibits the main characteristics of learning software targeted towards ASD individuals. CPG includes many images that the participants enjoy and the goal is very simple and straightforward. The user can change the level of difficulty to tailor the needs of the players. This is important in order to ensure that the puzzle is possible with their skill level. This interface also employs numerous visual and auditory feedback signals. Music, animations and sounds to enforce correct moves and suppress incorrect moves.

Battochi used this tool to test the effect of EFC on collaboration. In doing so, he conducted two studies: one involving boys with "typical development" and one involving boys with ASD. In these studies, the children paired with another student and tried to solve the given puzzle. In the first study involving the "typical" students, a group was required to use EFC and the other group was allowed to use Free Play (FP), which allowed the children to make puzzle moves independently on the screen. Similarly the autistic children had to complete the puzzle with EFC and FP, but all groups involved had to use both. Through an evaluation of task completion time,

number of moves, rate of simultaneous activity and relative interaction time, the researchers were able to make some conclusions regarding the use of EFC. They found that EFC clearly became more challenging in both studies as it took longer and increased the total number of moves, but it also was effective in increasing shared activity. This supports an impact of EFC with technology games for children with ASD. They conclude that in the application to ASD, EFC focuses on developing negotiation, shared attention and imitative behaviors. This game was part of a research study and is not available in the market.

Figure 2.3. Collaborative Puzzle Game that encourages teamwork and communication
(Battocchi, 2009)

2.5.2. Untangle

Untangle is a puzzle application that requires players to untangle lines between two loops on a touch screen (Hourcade, 2010). There are two versions of this game; the first has circles of one color, and the second has circles of two colors. The second version aims to stimulate coordination and communication by giving each player the task of untangling one of the two colors. In the second version of this game, each player has to ask the other one to continue after they are done with their turn. There are different levels of difficulty varying from 10 to 25 circles

in the puzzle. The environment of the game is simple and it keeps track of the number of moves and the time it took for the players to solve the puzzle.

This game also had a number of promising results and was effective in increasing attention span and social interaction on a number of occasions. In one particular case study, the test subject, Jane, showed significant improvement after several weeks of using this tool. At the beginning, Jane was uninterested in staying on one activity for more than a few minutes, but after continuing to use this game, she was willing to participate for much longer periods of time. Additionally, though she was at first unwilling to work with others on this game, Jane was soon able to collaborate with another child and give and receive suggestions in order to solve the puzzle more effectively. Soon, she was even able to instruct another child on how the game was played and was reluctant to leave her session when they were done for that day. Overall, she showed much improvement and greatly benefited from this play therapy.

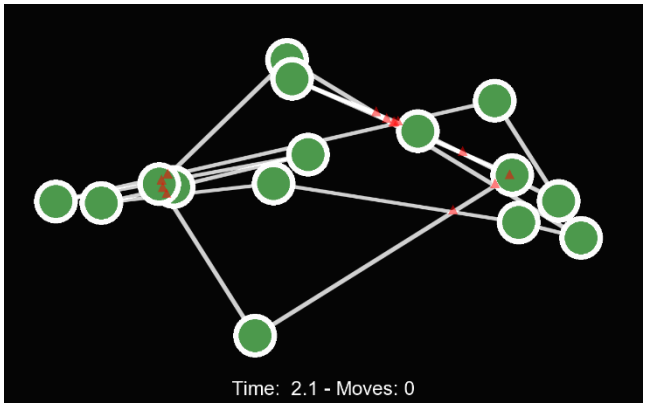

Figure 2.4. Untangle, a logic and problem solving collaborative puzzle (Hourcade, 2010)

2.5.3. PAR

PAR is another collaborative multi-touch game. Silva et al. (2014) designed and tested this tool on a specific target group. The goal of the game is to ultimately provide the soccer player with the appropriate clothing (shirt, shorts, and sneakers). In this game, players had to ship the uniform to the player in a cart. In order to get all the items needed into the cart, they must be taken off of the shelf, put into boxes and then placed in the cart. Based on the age, gender, and interests of the test subjects, the designers created an objective that would keep the students engaged. This tool consisted of four main phases that used different collaborative patterns (discussed in Section 2.4.) In each activity, one player would stand on either side of the tablet seen in Figure 2.6.

Five children used this software for fifteen days over the course of six weeks. Each session lasted between five and fifteen minutes where two users participated, along with a researcher and evaluator who facilitated and observed the interactions. Each phase of the game incorporate a different collaborative pattern. In each trial, the child was able to play the game at each phase and experimenters observed changes in social interaction across the patterns. Observations included verbal and gestural interactions. These interactions fell under the category of either as Interactive Situation (INSs), which are expressions that led to a response from the partner, and Interaction Intentions (IINs), which are expressions that did not lead to a response.

This study concluded that these patterns triggered new interaction expressions. These expressions include higher motivation to perform activities at a faster rate and cooperation with the use of verbal and physical communication cues. The unrestricted patterns provide an environment for users to voluntarily initiate collaboration.

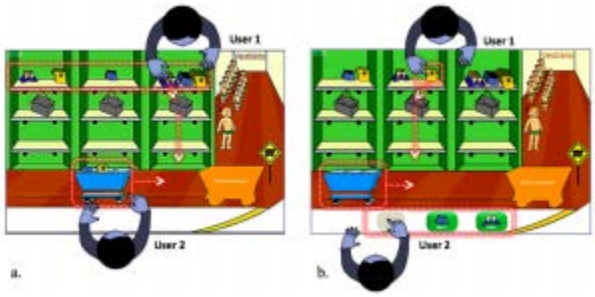

Figure 2.5. PAR, a collaborative puzzle game used to study collaborative patterns (Silva, 2014)

2.5.4. APPYautism

There is a category of websites that serve as search engines for tested learning applications focused on individuals with autism. There are several websites with similar purposes like *healingautismandadhd.com*, *massmatch.org* and *autismresearchfoundation.com*, but this section chooses to review APPYautism in more detail.

The purpose of APPYautism is to assist people with ASD, their families and all professionals related to ASD treatment by offering a selection of the best applications for Windows and Mac computers and for Android, iOS. and Windows Phone machines (Fundacion Orange, 2014). APPYautism is a search engine that enables the consumer to explore the available apps and filter results based on their needs. These system components include operating system, device, category (learning, social/behavior, leisure and communication), and a key word search bar (Fundacio Orange, 2014). Application costs on this site vary from free to $1000. The applications available focus on different educational areas, such as vocabulary, facial expressions recognition, feelings categorization, objects usage, social interaction, storytelling skills, mathematics and more. The main characteristics among these applications are the ease of use, the colorful graphics, the slow pace and the specific educational goal. The majority of the applications are for individual use

and since smart devices have been introduced in our daily lives, these applications can be used everywhere fast and with no additional cost.

Figure 2.6. APPYautism, a data base of ASD learning applications (AppyAutism, 2015)

2.6. Callaghan Innovation's Research and Current Product

Callaghan Innovation researches the effect of technology in collaborative games for children with ASD. They designed a collaborative game which they implemented in three different modes and then they observed and analyzed the results based on children's behavior and actions during the game. They used their research to design a new collaboration tool, "Talk-To-Me", which is very effective in helping children's communication and collaboration skills (King, 2015).

The method Callaghan Innovation used was a Face Match game with three different modes (cards, robot, Smart Board). The participants played this game for three days, every day in a different mode for approximately 15 minutes (Jordan, 2013). A game organizer was present to supervise, guide and help the participants. This research was in collaboration with the University of Otago Human Ethics Committee. The six participants (three with ASD, one who had suffered a stroke, one with cerebral palsy and one with Duchenne muscular dystrophy) played in pairs using each interface mode (Jordan, 2013).

The “Face Match” game is based on a traditional memory game. In each round a player can choose to flip two cards and must try to match them to earn points. Callaghan collaborated with iORA to develop the software for the game used on the smartboard and the robot. They also found that the participants preferred “games that included images of themselves or of individuals with whom they were familiar”. Therefore, they used photographs of themselves and of other familiar people on the cards.

In the three tests they used three different tools. They laid physical cards face down on a table in one of the trials. They also used Yujin, the robot which is shown in Figure 2.8, to facilitate the game. The robot includes a touch screen in which the face matching game took place and would turn to the student as they took their turn. The last method tested was the use of a SmartBoard, which is a large touch screen projector that, in this case, displayed the face match game.

Figure 2.7. Yujin, robot used in Callaghan Innovations Face Match study (Jordan, 2013)

Callaghan recorded the behaviors of the participants during the game in order to analyze them in detail. They recorded the participants playing the game every day for every mode. Then, they watched the videos and they identified 16 subcategories of behavior (Jordan, 2013). They grouped the participants’ behavior into two categories, the interaction (useful behaviors) and intra-

action (un-useful behaviors). Interaction include behaviors like increased attention and problem solving. The behaviors where the participant did not pay attention to the game and did not communicate belong to the intra-action category. Researchers also measured the “attention” and the “lack of interest” time periods.

This research does not indicate that the robot mode was the ideal learning tool but it does show that there are some positive characteristics technologies can emphasize to get better results. After this study, Callaghan chose to direct their attention away from robots and is not within the scope of this project.

Talk-To-Me is the current product of Callaghan Innovation. It is a communication tool that encourages children to have a conversation by taking turns and asking each other general questions. It has a simple interface with symbols that allows them to learn the rules of conversation. It is a tool that aims to assist children with ASD to cooperate, express themselves, communicate and socialize. The feature that makes this tool special is its shared platform for children that has a customizable interface for the caregiver to create conversation topics they want the child to practice on.

A test of Talk-to-me on four children with ASD gave some very positive feedback to Callaghan Innovation. A session with this tool can be seen in Figure 2.8. These children, who normally have attention spans of up to three minutes, as well as social interaction, held a continuous conversation for 20 minutes with the minimal intervention of their supervisors. Their speech and language therapist confirmed that it is an astounding result for these children and they observed excellent social interaction (Marcus King, 2015).

Figure 2.8. A trial of Callaghan Innovation's Product, Talk-To-Me (King, 2015)

2.7. Market for Collaborative Learning Tools

In this section, we investigate the market of learning software from a global and a New Zealand perspective. We review and explore the market segments globally as well as in the U.S. and New Zealand and consider certain commercializing methods that may be helpful for our sponsors.

2.7.1. New Zealand Market

One of New Zealand's important market segments for learning software for children with ASD is the group of government funded organizations that provide this software to the public for free. This market segment is interested in software in general.

Te Kete Ipurangi (TKI - The Online Knowledge Basket) is New Zealand's bilingual portal which operates under the supervision of the Ministry of Education. It is a website that provides New Zealand schools and students with resources, information, and curriculum materials and aims to raise student achievement and to advance professional development for teaching staff and school managers (Te Kete Ipurangi, 2014). One of the services that this portal provides is software for assistive learning, which includes learning software with children with ASD. Although their applications up to now do not include collaborative learning software, based on their goal to raise

student achievement we can infer that they would be interested in the product of Callaghan Innovation.

2.7.2. Global Market

Palo Alto Software identified three distinct market segments that are interested in educational software for individuals with ASD (Palo Alto Software, 2006). The first segment includes centers for independent living. These are typically non-profit entities that assist individuals with developmental disabilities. The centers help clients with transition skills, making them more independent. These centers offer a wide range of life skills training for the individuals.

Additionally, school districts comprise a very important market segment. All students are guaranteed an education therefore the school districts must provide the appropriate education. School districts are consumers of these products in pursuit of their goal of providing the students with an appropriate education.

Proactive parents comprise overwhelmingly the biggest and most important market segment (see Figure 2.9). This group consists of parents of individuals with developmental disabilities who are taking an active role in their child's education. Reinforcing these skills as much as possible is useful, therefore there is enough potential in the parents' market segment for learning software products for children with ASD.

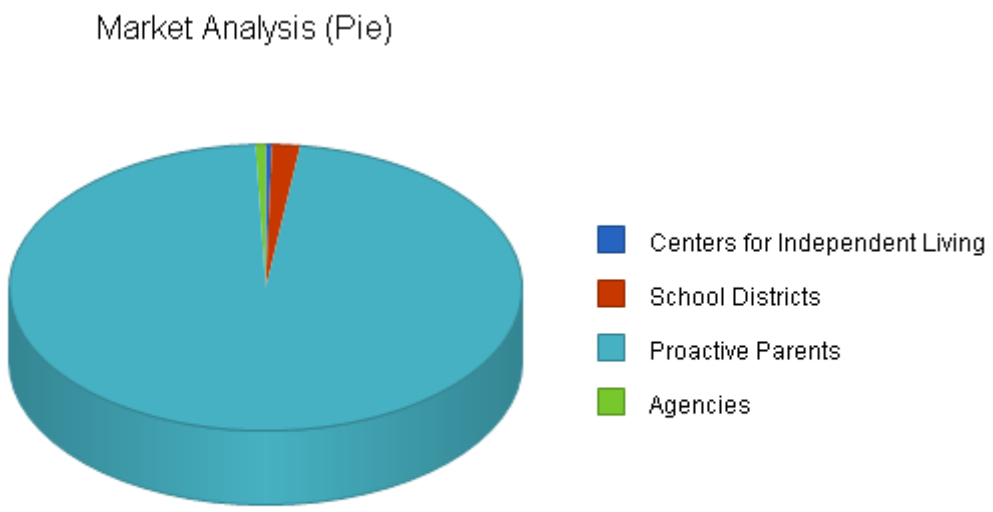

Figure 2.9. Global Market Analysis Pie Chart
(Palo Alto Software, 2006)

2.7.3. United States Market

Cuello estimated that the United States of America would spend about $1.48 trillion in 2007 with approximately 33% of state spending in support of education (Cuello, 2006). He further estimated that State Information Technology (IT) spending in fiscal 2007 would be $23.7 billion. In addition, local IT spending, which is growing at a higher rate than state spending, was approximately a $27.2 billion market with approximately 60 percent going towards education. Specifically, total US spending on special education was close to $52 billion with $600 to $700 million going towards instructional software and software supporting IEPs. Figures 2.10 and 2.11 include information about the total amount of estimated capital in special education in the US.

Targeted special education spending	$50 billion
Targeted "regular education" spending	$28 billion
Spending on other special ed programs	$2 billion
Total	$80 billion

Figure 2.10. Total Estimated US spending on Special Education for 2007 (Cuello, 2006)

Instructional software & assistive technology	$300 million
Instructional hardware	$400-$500 million
Administrative software; Individualized Education Plans	$300-$400 million
Technology-related staff development	$80-$100 million

Figure 2.11: Estimated Special Education Expenditures on Technology in US for 2007 (Cuello, 2006)

The total market size for the learning software product line consists of the sum of potential consumers in the public school, private school and home markets (Cuello, 2006). There are close to 49 million students in approximately 95,000 public schools divided into approximately 14,000 school districts. Additionally, in 2006, there were approximately 27,000 private schools in the US, comprising of 6.2 million students (Cuello, 2006). Approximately 67% of the 114 million households in the U.S. include school age children, which is translated to 78 million households (Cuello, 2006).

This data is fairly old and price of products as well as the market value has since changed and we intend to continue to look for more recent data. We can infer that the learning software and assistive technology market is currently developing in the U.S. and that there may be some opportunities for Callaghan Innovation's product. The U.S. appears to have a market of sufficient size to attract our sponsor's interest. This is preliminary knowledge in regards to the product and

further information on the current market situation will be collected on site and explained in section 3.1.

2.7.4. Competition to Callaghan Innovation

It is important to investigate other companies in New Zealand and in the rest of the world that have the same target market and try to sell similar products because Callaghan Innovation needs to be aware of the competition of this market. Providing Callaghan Innovation with research on its competitors will help them compare their strategies and products to make educated decisions.

Thus far our research has found three main companies that focus on individuals with developmental disabilities or individuals with autism as of 2006. They are the main competitors of Callaghan Innovation in the educational technology world-widely for ASD individuals sector (Palo Alto Software, 2006).

WordWise is a company that makes several products including picture-based language programs, laminated picture cards, and community success CD's. While their software has a grocery shopping module, it is very simple and limited in the choices of grocery items.

Edbydesign.com is a company that has several products including: sentence maker, match maker, counting programs, and sorting programs. These are all non-interactive CD-based programs.

Autismcoach.com is a company that makes software that is designed to strengthen core cognitive skills such as short-term memory, mental processing speed, multi-tasking and auditory processing. This is primarily for a younger customer age of 10-17.

We located one company in New Zealand that focuses in the learning software for children with or without learning disabilities. "The Learning Staircase" was founded in Christchurch, New

Zealand officially launched the software program “Steps” in 2001. They describe Steps as a highly effective, research-based literacy software program which is enjoyable and easy to use. However it does not belong to the category of collaborative learning software. Over 600 schools use Steps in New Zealand and it is also used extensively abroad, especially in Australia, UK, Ireland, India and Dubai (The Learning Staircase, 2015).

Additionally, we identified characteristics of their marketing strategy. Learning Staircase provides free trials for parents, schools and tutors. They offer individual game sets (applications) for NZ$17 - 48 and the Steps, Wordshark, Numbershark and Booster software programs for NZ$72 - 250. They provide different editions of the Steps software depending on the customer (parent, tutor) and on whether the buyer wants an online subscription or just the CDs.

The specific games and collaboration tools described earlier in this section can also be seen as competitors because they have designed products that accomplish similar goals, however, they do not currently pose an economic threat to Callaghan because none of these products are being sold for profit.

2.8. Summary

Autism is a condition that affects people worldwide and utilizes a range of treatments. There are many aspects to understanding the ASD community in New Zealand and the use of collaborative learning tools in this environment. Collaborative learning is a growing technique and researchers have found evidence that supports that technology can be an effective tool to facilitate these activities. Callaghan Innovation has developed a product Talk-to-Me and asked us to evaluate the potential market for this product. Therefore, it is important to understand products and organizations with similar goals as well as the actual market for information and

communication technology. This information will provide insight to our project and guide data collection to determine the feasibility of putting this product on the market.

Chapter 3: Methodology

This project is intended to assist Callaghan Innovation in improving social and learning skills in children with Autism Spectrum Disorder through the use of collaborative technology in New Zealand. This research involves investigating current products in the educational technology market and ascertaining the needs of the parents, teachers, and therapists associated with children with disabilities for these types of products. Our team will evaluate the potential market for Callaghan's current product, Talk-to-Me, and provide recommendations on the design of assistive learning technologies and applicable commercialization techniques to create a successful international manufacturing business.

We plan to accomplish these goals for Callaghan Innovation through the following objectives:

- Understand Callaghan's goals, resources, and challenges with regards to their product commercialization.
- Investigate the potential need for Callaghan's current product for stakeholders in New Zealand
- Identify effective characteristics of collaborative assistive learning technologies for children with ASD.

A visual representation of our methodology can be seen in Figure 3.1 below:

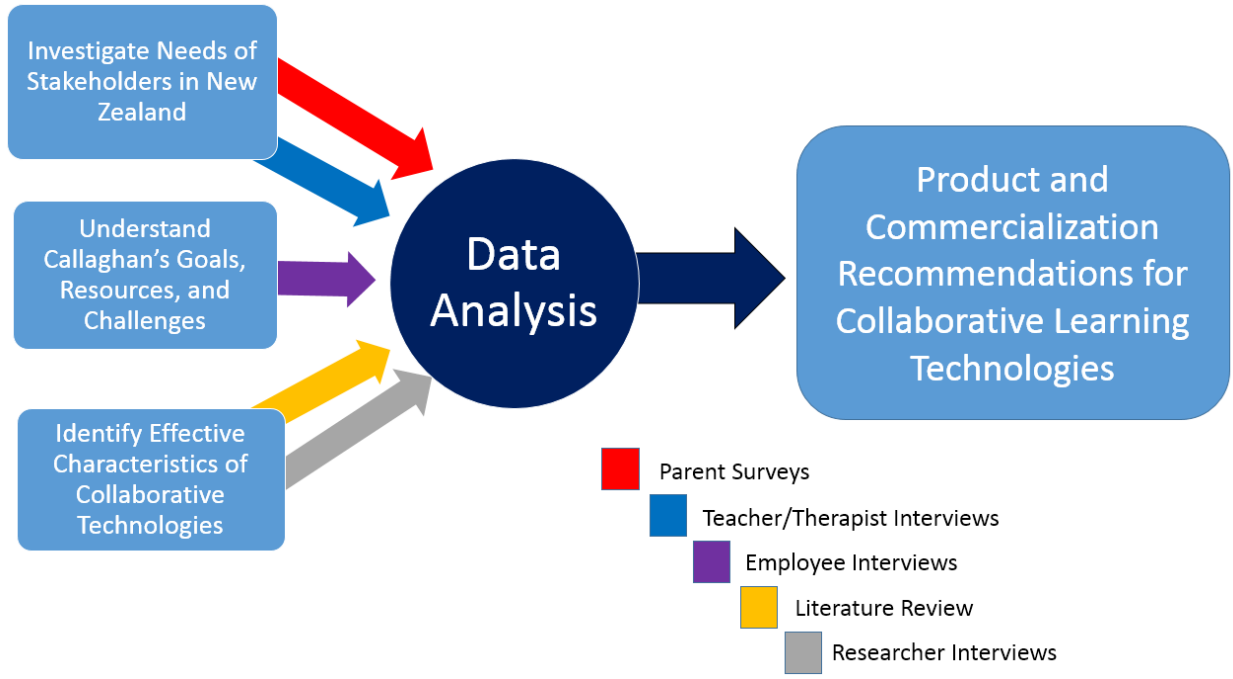

Figure 3.1. Methodology Diagram

3.1. Understanding Callaghan's Goals, Resources, and Challenges

Callaghan Innovation develops and commercializes a wide variety of products. To recommend ideas to this company, it is important for us to understand all aspects of the company. It is important to determine the goals that Callaghan has for their products and research. We also would like to understand the resources available and the challenges they face in commercializing their product. Additionally, after contacting our sponsors we understood their need to commercialize their product as effectively as possible. In our first interview our sponsors mentioned that Callaghan Innovation had a lot of experience with developing effective products but they lack experience in the commercializing sector. Because Callaghan has difficulty getting their product to the market, it is important to understand their commercialization methods in New Zealand and internationally. In order to accomplish this objective we plan to contact experienced

people in marketing at Callaghan Innovation and at some other organizations like New Zealand Trade and Enterprise (NZTE) and New Zealand Technology Industry Association (NZTech).

Callaghan Innovation has a number of sectors that develop and distribute a variety products. We plan to contact the administrators of these products in Callaghan Innovation who have already commercialized or are in the process of commercializing their product. We will ask our sponsor to help initiate contacts with other members of the company for these interviews. Most of the information will be gathered by both face-to-face and Skype interviews in Callaghan's headquarters in Gracefield, New Zealand and will include questions relevant to how they perceived their market, whether they used a specific technique to commercialize their product and how they changed their product in order to make it more attractive to their target market (Appendix F). We would also like to see what kind of recommendations they have for the future of Callaghan Innovation. As for our method, we plan to do semi-structured interviews because they allow for a little discussion off of the main questions (Berg, 2012). By speaking with these representatives, we will better understand how Callaghan Innovation functions as a whole. After our interviews, we will analyze extensive notes and will use coding to evaluate the data. We will use this information in order to create recommendations specific to the Talk-to-Me project.

Moreover, Callaghan Innovation can connect us with their partners and guide us on who we should contact to investigate commercializing methods for their product by following the snowball effect during our interviews. Previous collaborations of theirs will be of high importance for our research and this will help with analyzing of global commercialization for their current and future products.

During our research we found two organizations that could give us valuable information about exporting from New Zealand, global product restrictions and key methods of

commercializing products globally. One of them is NZTE. NZTE is the Government's international business development agency whose purpose is to grow companies internationally for the benefit of New Zealand (NZTE, 2015). They use their connections and government influence on behalf of businesses, and apply local knowledge to help them enter and grow in international markets. These two groups are partners with Callaghan and may help us and answer some of our questions regarding globalized commercialization. The information can be gathered by semi-structured interviews that will allow us to focus on specific questions we have and at the same time discuss issues that the responders bring up (Berg, 2012).

The other organization that we can contact in New Zealand is NZTech. NZTech is an association whose vision is "more prosperity for New Zealand through better use of technology". NZTech Supports the growth of New Zealand technical businesses and their export capabilities are a core strategic focus area for them (NZTech, 2015). By contacting this association we can learn about people and other businesses that have experience to a sector close to Callaghan Innovation's product.

3.2. Investigating the Needs of Stakeholders in New Zealand

One important objective of this project is identifying the needs of the various stakeholders involved in the ASD community who would be affected by these assistive technologies. These stakeholders, including teachers, therapists, and parents, will be vital in acquiring information about the need for this type of product. In order to gauge interest and identify what is important to these stakeholders, we plan to have a set of interview questions that ask about their opinions on these technologies and past experiences. Given that the New Zealand school system is on summer holiday from December to February, we anticipate having difficulty acquiring face-to-face

interviews with this stakeholder group. Therefore, we intend to utilize phone interviews and surveys in order to get in contact and retrieve the data about their product needs. Given that detailed responses will be very important in order to get all the relevant data, we will try to maximize the information we receive in our interviews by using a semi-structured question setup. One school nearby in Wellington that we hope to contact is the Kimi Ora School that is specifically for children with learning disabilities. There are other schools farther away in areas like Christchurch and Auckland that we are also planning on contacting. Additionally, we are looking into summer programs for children with ASD that could lead to more available professionals to interview.

The first group of stakeholders we aim to interview is teachers and therapists who are directly connected to the ASD community. In our research thus far we have found that most advanced assistive learning technology tools are still in research and development and the companies have not yet released them on the market. Therefore, we anticipate that most schools and therapists will not be utilizing this type of technology, but could be interested in doing so in the future. The questions for this specific interview can be found in Appendix C. We intend to use these questions to gauge the amount of interest in this type of assistive learning technology in general in order to see if Callaghan's product could have a place in these schools. However, since Talk-to-Me is not yet marketed, we would be unable to discuss the particulars of the product with these stakeholders. In these interviews, it would be helpful to show them an example of collaborative technology tools that have been designed for research and get their feedback on what potential they see for a product like this and personal interest they have in owning this tool. It would also be necessary to inquire about current methods and low-tech tools that they are currently using in order to determine the methods necessary for an assistive product to be successful. These interviews would also gauge if the teachers were content with the tools they have access to or if

they believe that more advanced technology would be useful in the school room. They could additionally provide input as to constraints on acquiring these products by discussing budgets and feasibility of integrating the products into the current curriculum.

Parents are another important stakeholder group in this research because of their direct connection to the children who would be using the products. We plan to use an online survey (a preliminary survey can be found in Appendix E) instead of a face-to-face interviews in order to get in contact with parents of children in the schools and programs mentioned above. The survey will be short with multiple choice questions to minimize the time it takes to complete and maximize the number of helpful responses we receive. The goal of this survey is to understand the technology available in the home and used in educational therapy for children with special needs. This survey will gauge interest on whether or not collaborative tools, like Talk-to-Me, are desirable to parents and through an understanding of the ranking in importance of collaboration compared to other skills. Other questions inquire about their evaluation of the collaborative activities and technology that their child uses to understand what collaborative techniques are used in home therapy.

This information from these stakeholders will provide information that will be used to evaluate how Callaghan Innovation's product fits into the needs of these stakeholders. This data will be evaluated both qualitatively and quantitatively through multiple choice responses and coding.

3.3. Identifying Effective Characteristics of Collaborative Technologies

It is important to understand existing products and the advantages and disadvantages of each to be able to compare them to Callaghan's current product, Talk-to-Me. Appendix B itemizes 12 products that our preliminary research has identified as targeted for autistic children and that focus on encouraging collaboration. Researchers use these products to observe the impact they have on autistic children's social skills. None of these products are on the market, so it is unlikely

that consumers would have knowledge about this technology. To gather more information regarding the published work on the products, we aim to get in contact with these researchers via email in order to gauge their interest in sharing more information about their results with us. If they are willing, our goal is to then gather more information regarding their research by setting up a semi-structured interview or discussion through phone or Skype.

The first three questions of this interview will gather information on the status of their most recent product. We will ask if they designed a more recent product and ask them to reflect on what has worked well and what they would like to see in this research field. The second part of the discussion will ask them about the market for their product; if they haven't put the product on the market we would like to know why as well as the potential they see or don't see for profit. If they have put it on the market, we would like to gain information on the reflection of its success. These interviews will have a standard format so that we will be able to retrieve the same information from each researcher. However, the interviews will also have a number of open ended questions in order to get a better and more specific understanding of certain aspects of the research. This research will continue in New Zealand to identify current competitive market products to Callaghan Innovation. We will do an evaluation and an overall comparison of the different products similar to Talk-to-Me to present Callaghan with information on their competition. We will use a thorough analysis of them by comparing and contrasting their features and target markets.

3.4. Conclusion

In conclusion, this project's main focus is to evaluate the current state of assistive learning technology products and how well they satisfy the needs of consumers in order to give

recommendations to Callaghan to increase the probability of success of Talk-to-Me in the market. In order to achieve this goal, our group has found data on the current learning tools which will be compared to Callaghan Innovation's product and plan to get more information through communication with these researchers. We will also interview important stakeholders including parents, special education teachers, and therapists to learn about their needs and identify the qualities this product must possess to fulfill their requirements. Through these methods, we hope to achieve our project goal and have a positive impact on the New Zealand ASD community by helping Callaghan Innovation release the most effective version of a highly beneficial and valuable product. This data from Callaghan employees, parents, teachers, therapists, and researchers will help to evaluate the expected success of Talk-to-Me.

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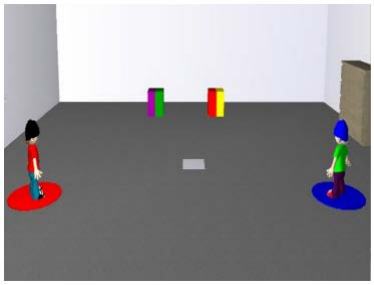
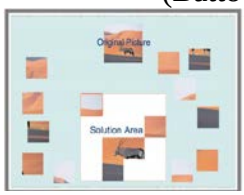
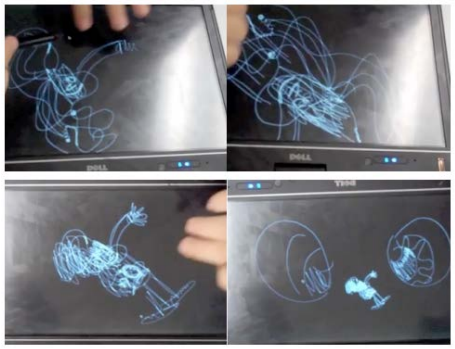
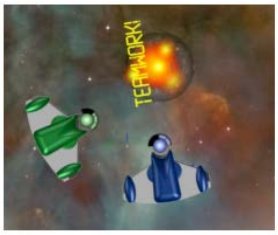
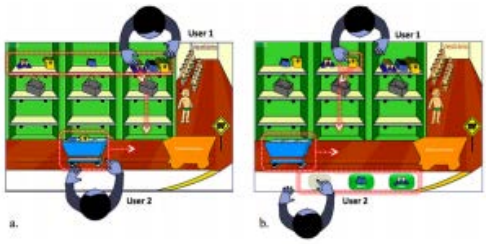
Appendix A: Disabilities Similar to ASD

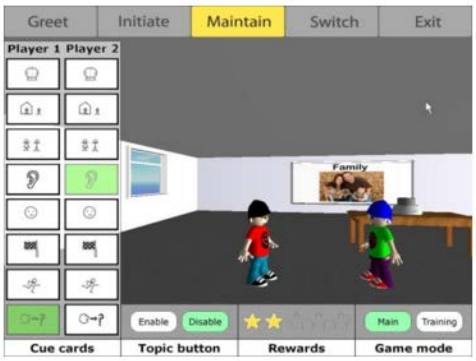
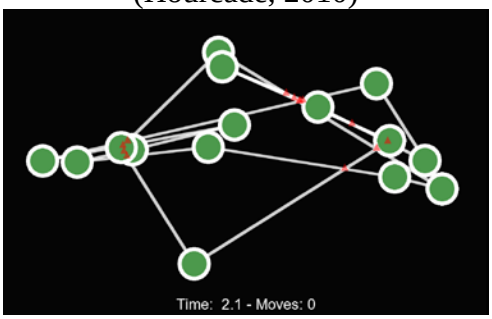
Attention Deficit Hyperactivity Disorder (ADHD) is characteristic of lack of focus and difficulty controlling behavior (National Institute, 2015). Fragile X Syndrome (FXS) is a genetic disorder that causes developmental delays in learning new skills and social problems including lack of eye contact and attention (CDC, 2015a). Fetal Alcohol Spectrum Disorders (FASDs) can be characteristic of hyperactive behavior, learning disabilities, poor judgment skills and difficulty with attention (CDC, 2015c). Children who have some form of mental retardation or Down syndrome often experience problems associated with ASD; these include behavior issues, intellectual disabilities, and lack of focus (WebMD, 2015). This is only a partial list of developmental disorders that exhibit similar characteristics to children with ASD. Many children with disabilities, across the board have difficulty reaching out to others because children with disabilities often lack confidence or physical capability that causes these interactions to be intimidating (MyChild, 2015). This includes disabilities that are not specific to mental dysfunction, like cerebral palsy and muscular dystrophy.

Appendix B: List of Current Collaborative Technology Games

Application	Tool	Description of Game
Block Challenge (FBK, 2008) 	CVE on computer w/headset	Each player controls an avatar and must work together to build a tower made up of different colored blocks
Collaborative Puzzle Game (Battocchi, 2009)  	Touch surface (DiamondTouch)	Puzzle that requires players to move pieces together
Drawing (Hourcade, 2010) 	Touch surface	Drawing game in which a child starts a story and draws in the same time. Then another child continues the story and draws on the previous drawing. This continues until all the children agree that the story is done.

Invasion of the Wrong Planet (Marwecki, 2013) 	Touch surface	Arcade game in which each player has control of their own space ship and they must shoot and destroy invaders to earn points
Music Authoring (Hourcade. 2010) 	Touch surface	Music composition game in which two children take turns picking tones on the screen to create a song
PAR (Silva, 2014) 	Touch surface	A game that requires one user to place various object in a box and a second user that then must collect the boxes in a cart and ship them

Reactable (Villafuerte, 2012) 	Circular table top where users can interact, both through direct contact with the table, and through objects called pucks grouped in four categories: generators, sound effect, controllers and global objects	The Reactable is a Tangible User Interface that allows the intuitive and collective creation of complex musical pieces.
SIDES (Piper, 2006) 	Touch surface DiamondTouch	At the beginning of a round, each player receives nine square tiles with arrows. Students are asked to work together to build a path with their pieces to allow a “frog” to travel from the start lily pad to the finish lily pad

StoryTable (Bauminger, 2007) 	Touch surface	One lady bug carries the backgrounds, the context within which the story will be set Another ladybug carries the various story elements that can be dragged onto the current background and create a story in this way.
TalkAbout (FBK, 2008) 	Desktop, laptop, tablet - Anything that can connect to the internet.	Children have an avatar in a virtual room and communicate with one another using microphone headsets. In TalkAbout, the session facilitator is also in the virtual environment and has their own avatar. They choose a topic that they want to discuss on and they start communicating via their avatars.
Untangle (Hourcade, 2010) 	Touch surface	The puzzle consists of a set of circles, each connected to two other circles by lines. To solve the puzzle, none of the lines should overlap.The goal of this application is to encourage communication, collaboration, coordination and visuo-spatial thinking.

Appendix C: Teacher/Therapist Interview

1. What kind of disorders do you treat/ come across? Only ASD or others as well?
2. What range of needs do you treat? Only low to medium or high as well?
3. How does the therapy differ from child to child?
4. What collaborative activities are used in your classroom/therapy session? Please specify the name of the activity.
5. Which of these activities involves technology?
6. How comfortable are you with using technology in your classroom and therapy?
7. OF THE GAMES THAT INVOLVE TECHNOLOGY:
    a. What technology tool is used in each game you previously mentioned?
    b. What did you like and dislike about each kind of technology that you have used?
    c. How successful were these games in teaching social skills to your students?
    d. Would you continue to keep using them?
    e. When you buy these products what do qualities you look for? What qualities would prevent you from buying these products?
    f. Do you know anything about Callaghan Innovation's current collaborative learning product?
    g. Would you be interest in a product like this and how much are you willing to spend?
8. IF NO THEN:
    a. Why have you not utilized any kind of learning technology?
    b. What has stopped you from doing so in the past? (Money, ease of access, just don't like, etc)

c. Do you plan to use any kind of technology in the future? Why or why not?

d. How much are you willing to spend on therapy products?

9. Would you be willing to refer us to any other schools, therapists, etc. so that we might interview them as well?

10. Would you be willing to allow us to send out an information gathering survey to parents in your school in order to learn more about this issue?

Appendix D: Survey for Parents of Children with Disabilities

Has your child been diagnosed with autism or another developmental disorder?

a. Yes
    i. Please specify the diagnosis: _____
    ii. Age: _____
    iii. Gender: M F
b. No

If Yes

2. Prioritize the importance of the following skills to be improved on your child (from 1 being the most important):

communication ____
problem-solving ____
grammar-vocab. ____
math ____
collaboration ____
emotional comprehension ____
other 1:_____ ____
other 2:_____ ____

3. Is collaboration used at all in your child's therapy?
    a. Yes
    b. No

4. If so, who is involved?
    a. Therapist and child
    b. Two children
    c. Parent and child

5. What forms of technology does your child have access to in your home? (Select all that apply)
    a. Smartphone/Handheld devices
    b. Computer/Laptop
    c. Tablet
    d. Video Game Console
    e. Handheld Video Game Console
    f. Other: _____

6. What forms of technology does your child use in therapy outside of school?
   a. Robots
   b. Smartphone/Handheld devices
   c. Computer/Laptop
   d. Tablet
   e. Video Game Console
   f. Handheld Video Game Console
   g. Toys
   h. Other:_____

7. Please identify all collaborative games and software used in child's therapy and answer the following questions:

(Each product that is identified will be listed in this column)	What are the target skills of this product (what is it designed to improve)?
Program X	communication problem solving grammar-vocab. Math collaboration emotional comprehension other 1:_____ other 2:_____

(Each product that is identified will be listed in this column)	How successful was this product in teaching these skills?
Program X	Very Unsuccessful Somewhat Unsuccessful Somewhat Successful Very Successful

(Each product that is identified will be listed in this column)	How satisfied are you with this product?
Program X	Very Satisfied Somewhat Satisfied Somewhat Dissatisfied Very Dissatisfied

8. How interested would you be in purchasing a collaborative learning tool? (Provide information on a product similar to Talk-to-Me)
    a. Very interested
    b. Moderately interested
    c. Somewhat disinterested
    d. Not at all interested

9. How much are you willing to spend on a therapy product?
    a. 0-10 NZD
    b. 10-50 NZD
    c. 50-100 NZD
    d. 100+ NZD

(Optional) Please elaborate on your satisfaction (what you like about it, what you dislike, what you would like to see improved, etc.):

Additional comments:_____

10. Would you be willing to participate in a more in depth interview on this topic?
    a. Yes
        i. Please provide your e-mail or phone number:_____
    b. No

Appendix E: Interviews with Researchers of Collaborative Learning Tools

Name:_____ Date:_____
Location:_____ Employer:_____
Product:_____ Date of Publication:_____
Relative publications:_____

- Is there any latest version of your product?

- What do you believe that are the important features of your product?

- Would you change something on your product?

- Have you commercialized your product?
    - What are your market segments? Are they dependent on location?
    - What is the price/cost of your product?

- If No:
  - How come it hasn't been put on the market?

_____
_____
_____

  - Do you see a potential market for this tool?

_____
_____
_____
_____

- Do you have any suggestions for further research in this field?

_____
_____
_____
_____
_____
_____