2022

Using applications on a digital device as intervention during therapy sessions to enhance the fine motor skills of children with autism spectrum disorder (ASD)

BOSTON UNIVERSITY

SARGENT COLLEGE OF HEALTH AND REHABILITATION SCIENCES

Doctoral Project

USING APPLICATIONS ON A DIGITAL DEVICE AS INTERVENTION DURING THERAPY SESSIONS TO ENHANCE THE FINE MOTOR SKILLS OF CHILDREN WITH AUTISM SPECTRUM DISORDER (ASD)

by

HOI KI KAN

B.O.T., Australian Catholic University, 2017

Submitted in partial fulfillment of the

requirements for the degree of

Doctor of Occupational Therapy

2022

Approved by

Academic Mentor

Cynthia Abbott-Gaffney, OTD, MA, OTR/L
Teaching Professional of Occupational Therapy
Boston University, Sargent College of Health and Rehabilitation Sciences

Assistant Professor of Instruction in Occupational Therapy
Temple University

Academic Advisor

Karen Jacobs, Ed.D., OT, OTR, CPE, FAOTA
Associate Dean for Digital Learning & Innovation
Clinical Professor of Occupational Therapy

DEDICATION

I would like to dedicate this work to two beloved people who have meant and continue to mean so much to me, my mother, Carry Law, and my partner, Karolis Kajenas. They have been wonderful supporters and encouraging me through my journey in this doctoral project. In addition, I am truly thankful to the rest of my family and all my friends who guide me through the valley of darkness with light of hope and support. Thank you very much and I love you all.

ACKNOWLEDGMENTS

I would like to give my warmest thanks to my academic mentor, Dr Cynthia Abbott-Gaffney, for her valuable guidance and encouragement in finishing my doctoral project. You provided me with the support and inspiration that I needed to choose the right direction and successfully complete my dissertation.

I would like to thank Dr Nancy Doyle who has provided helpful and valuable advice in my doctoral project.

I would like to thank the Boston University post-professional doctorate in occupational therapy (pp-OTD) program director, Dr Karen Jacobs, and all instructors. I have benefited greatly from all your wealth of knowledge and feedback.

I would like to thank Tiago Jesus and Elizabeth Kocher, my peer mentors, for incredible support and guiding me on the right path.

I would like to thank Emily Gaffney who has volunteered to assisted me in analyzing the existing applications in the market which was very helpful in completing one of my chapters.

To Karolis Kajenas, my partner and the developer of *Finger Up* for this project. Thank you very much for your effort, time and patience in creating *Finger Up*.

To my family and friends, thank you for your continuous support and understanding when undertaking my project. Your prayer for me was what sustained me this far.

USING APPLICATIONS ON A DIGITAL DEVICE AS INTERVENTION DURING THERAPY SESSIONS TO ENHANCE THE FINE MOTOR SKILLS OF CHILDREN WITH AUTISM SPECTRUM DISORDER (ASD)

HOI KI KAN

Boston University, Sargent College of Health and Rehabilitation Sciences, 2022

Major Professor: Cynthia Abbott-Gaffney, OTD, MA, OTR/L, Lecturer of Occupational Therapy, Boston University, Sargent College of Health and Rehabilitation Sciences; Assistant Professor of Instruction in Occupational Therapy, Temple University

ABSTRACT

Fine motor skills are important for children to participate in their occupations, including self-care, productivity and leisure. The deficits of fine motor skills are common in children with autism spectrum disorder (ASD), and as a result, they experience difficulties performing daily tasks. Digital devices, such as touch screen devices, has been found to support children with disabilities learn and develop their life skills (Alaniz et al., 2015; Dehghan et al., 2017; Seo, 2018). However, a lack of training on how to use applications and insufficient settings have discouraged occupational therapy practitioners (OTPs) to continue using applications on a touch screen device, regardless of the effectiveness (King et al., 2017;). In this project, an application, *Finger Up*, has been developed based on theoretical frameworks, evidence-based literature, and an online survey completed by OTPs.

Results from the online survey revealed that the limitations of the existing applications include 1) a lack of visual display for monitoring progress, 2) a lack of visual rewards, 3) a lack of sound rewards, 4) a lack of visual effect for wrong answers, 5) a lack

of sound effect for wrong answers, 6) busy background and sensitivity settings, and 7) not colorful. The features suggested from the survey results are 1) simple to use, 2) simple layout, 3) a timer, 4) sounding effect for wrong answers, 5) visual rewards, 6) visual effect, 7) simple instruction, and 8) setting a time limit for each game. OTPs will receive three training sessions prior to the implementation of *Finger Up* with their clients. Once the training sessions are complete, OTPs will use *Finger Up* with their clients, 5–11-year-old children with ASD, in a 30-minute therapy session, 5 days a week, for 3 months. A pre- and post-assessment will be conducted for comparison to investigate the effectiveness of *Finger Up*. Long-term impacts of the program seek to improve the fine motor skills of children with ASD using *Finger Up* with the suggested protocol and promote technology use in occupational therapy.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ASD ..... Autism Spectrum Disorder

BU ..... Boston University

DOI ..... Diffusion of Innovation theory

DSM-IV ..... Diagnostic and Statistical Manual of Mental Disorders

IRB ..... Internal Review Board

MABC-2 ..... Movement Assessment Battery of Children – 2nd Edition

OT ..... Occupational Therapy

OTPs ..... Occupational Therapy Practitioners

PEOU ..... Perceived Ease Of Use

PU ..... Perceived Usefulness

TAM ..... Technology Acceptance Model theory

UK ..... the United Kingdom

US ..... the United States

WFOT ..... World Federation of Occupational Therapists

CHAPTER ONE – Introduction

Introduction

An occupation encompasses the activities we do in daily life, the things that make us who we are and the things we do to make the most of life (Brown & Hollis, 2013). Health, wellbeing, and life satisfaction are largely dependent upon the ability to engage in meaningful occupations (Brown & Hollis, 2013). Occupations of children include play and learning. When the ability to perform these occupations is affected by a condition, such as autism spectrum disorder (ASD), a child's independence, health and emotions will consequently be impacted (Rodger & Ziviani, 2006).

Scope of the Problem

ASD is a developmental disorder that limits an individual's ability to perform occupations (self-care, productivity, leisure) independently and properly (Lord et al., 2018). Creek and Bullock (2008) stated that how people engage in activities and their development are influenced by environmental opportunities and barriers. The study further explained that child development will not proceed normally if the child is deprived of a normal range of purposeful activities (Creek & Bullock, 2008). According to the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) (American Psychiatric Association, 2013), ASD is clinically characterized by different features, include impairments in communication and social interaction, difficulties processing sensory information and presence of restrictive repetitive and stereotypical behaviors, interests, or activities (Kushki et a., 2011; Lord et al., 2018). Apart from these core deficits, ASD is related to a high prevalence of fine motor difficulties and impairments in executive function

that lead to learning and performance of skilled motor tasks (Kushki et al., 2011). Both gross and fine motor skills are important for a successful completion of daily tasks, such as self-care, schoolwork, job duties and leisure activities (Kruger et al., 2019).

Implications of the Problem

Zikl et al. (2016) stated that children with ASD have a lower level of fine motor skills compared to their gross motor skills. In 101 children aged 10–14 years old with ASD, 79% were found to have impairments in fine motor hand skills of the Movement Assessment Battery for Children (Green et al., 2009). Fine motor skills occur when we make movements using small muscles in our fingers, wrists, hands, and forearms (MacDonald et al., 2013). Fine motor skills are used when completing self-care and school-related tasks, such as dressing (tying shoelaces, doing zips or buttoning), eating (utilizing cutlery, opening lunch boxes, or holding a cup), handwriting (writing or holding a pencil), or using scissors (Kim et al., 2018; MacDonald et al., 2013). Children with ASD have displayed a weakness in fine motor skills and this can lead to poor school performance, which then contribute to low self-esteem, decreased confidence and a poor quality of life (Bhat, 2021; Memari et al., 2015 Zikl et al., 2016).

In addition, Kruger et al. (2019) stated that there is a significant association between these skills and the level of ASD. For instance, children with a more severe level of ASD tend to have greater deficits in motor skills. In this study, those who actively participated in physical education classes obtained higher scores in motor skills which are strongly associated with independence level in activities of daily living (Kruger et al., 2019). Hirata et al. (2014) also investigated and showed that children aged 7–16 years old with ASD who

have more difficulties with manual dexterity tend to have more severe social impairment. Finally, a study also showed that fine motor skills are an important factor in cognitive development in our early childhood and are a significant component of children's activities at school (Kim et al., 2018), rounding out the importance of fine motor skill development and its impact on acquiring necessary performance skills throughout the life span.

Role of Occupational Therapy (OT)

The role of OT with children is to improve their independence skills, to help with their ability to self-regulate their emotions and to guide them on how to effectively participate in social interactions with others. ASD is categorized as a client factor according to the Occupational Therapy Practice Framework (The American Journal of Occupational Therapy, 2014) and can negatively impact the daily performance of children. The affected client factors often accompanying ASD include gross and fine motor, concentration and attention, social interaction, and communication skills (Lord et al., 2018). As a result, the daily function of children with ASD is also affected, including their habits, routines, and roles. For children with ASD, OT practitioners (OTPs) aim to help them develop skills for daily living, for school-based activities, for fine motor skills, and for social interaction skills (Hung & Fong, 2019; Domínguez-Lucio et al., 2022). Touch screen devices have become effective intervention tools to use in OT. For instance, OTPs use applications on touch screen devices with children with ASD to work on their social communication skills (Hung & Fong, 2019). In addition, OTPs also motivate children with ASD by using applications on a touch screen device to enhance their participation and engagement in therapy sessions (Domínguez-Lucio et al., 2022).

Trend of using screen-based therapy

A study showed that technologies are not only commonly used for education in developed countries, such as Japan and Europe, but they are also used in developing countries, such as India and Africa (Hamidi et al., 2011). The trend of using technologies for education is growing in both developed and developing countries to allow students to learn effectively. However, compared to developed countries, developing countries are less equipped with information and communication technology, which raised a concern for the researchers (Hamidi et al., 2011). In addition, another study completed in Malawi, one of the least-developed nations in the world, stated that there is a high rate of children who are not in school and those who attend school do not learn to read or write (Horn, 2019). Around 5,000 students are enrolled annually in a school situated in the capital city with 200 students sitting on the floor while one teacher holds up a single book (Horn, 2019). In order to maximize the students' learning capability, a non-profit organization, Imagine Worldwide, conducted an experiment to test whether students can learn to read, write and do basic math using technology with limited or no instructions from adults (Horn, 2019). After 15 months of this experiment of using technology in teaching, the results showed that 66% of 1 billion students were able to read and answer single-digit addition and subtraction (Horn, 2019). The results of this study suggested that children benefit from using technology in learning educational skills.

In addition, according to a poll conducted by American Occupational Therapy Association (AOTA), more than half of therapists have utilized mobile applications, in their practices (Yamkovenko, 2018). Studies also stated that there are various advantages

to using a touch screen device with clients during therapy, including improved brain function, longer concentration, enhanced speech, a significant decrease in stress level, facilitation of opportunities to learn writing with fingers and improved numeracy skills (Chmiliar, 2017). Using a touch screen device, such as an iPad, helps users complete daily tasks and can easily accommodate different learning styles and the user's current knowledge (Allen et al., 2016). Mobile applications on devices allow users to access and repeat using the materials that they can learn from anywhere without a time limit (Allen et al., 2016). Users can also adjust the level of difficulty and the quantity and type of support to help them learn (Akbulut & Cardak, 2012).

Proposed Solution

This doctoral project involved a participatory action research study designed to investigate experiences using applications and tablet interventions addressing fine motor skill in occupational therapy sessions. The results of the author's original survey combined with findings in evidence-based literature were then used to design a touch screen application, *Finger Up*, for use in OT sessions focused on the development of fine motor skills.

In future phases of this project, six children aged 5–11 years old with ASD will be recruited. Three of the participants (experimental group) will use the newly developed application on a touch screen device, such as an iPad; whereas others (control group) will not have access to it for 3 months with a therapy session every day, 5 days a week. All participants will receive a half hour therapy session during which three participants will need to complete screen-based tasks while others complete paper-based tasks. Prior to and

after implementing this intervention, three fine motor subtests (fine manual control, manual coordination, and fine motor composite) of the Movement Assessment Battery of Children – 2nd Edition (MABC-2) is administrated and conducted to each participant by OTPs. Survey and/or interviews with parents and schoolteachers will be used to gather more qualitative information. It is anticipated that outcomes will reveal participants from the screen-based group will receive higher performance scores in three subtests of MABC-2 demonstrating more significant gains in fine motor skills when engaging in the use of applications targeting fine motor skill improvement using a touch screen tablet.

It is hypothesized that the outcomes of the doctoral project will support these points:

- Children with ASD who utilize applications on a device during therapy session will demonstrate average or above average scores in three fine motor subtests of MABC-2 after 3-month implementation.

Participants who do not use applications on a device during therapy session will produce the same grade (below average or well-below average) in three fine motor subtests of MABC-2 after 12-week implementation.

CHAPTER TWO – Project Theoretical and Evidence Base

Introduction

This chapter presents an overview with a visual representation of a proposed explanatory model of the present problem and the causal factors contributing to the impact of the problem. The chapter then highlights the theoretical framework used for project development and implementation.

Overview of the Problem

Fine motor skills are important to child development as they are the foundation for the development of many other important skills in the future, such as writing and self-care tasks. Children with autism spectrum disorder (ASD) commonly show signs of fine motor deficits and other associated impairments. These deficits can negatively impact on their daily activities and quality of life. With the increasing trend of using technology, more schoolteachers and therapists use touch screen devices in teaching (Sung et al., 2016). However, there are limits to the efficacy of existing applications dedicated to improvement of fine motor skills.

Strengths and limitations of touch screen devices

Research showed that students with and without disabilities gained benefits from using any technology, including touch screen devices; however there are concerns. King et al. (2017) stated that some applications give “rewards” for incorrect answers which fails to provide differential feedback between correct and incorrect answers. Hence, this can potentially confuse users. Health professionals explained that it is essential to include

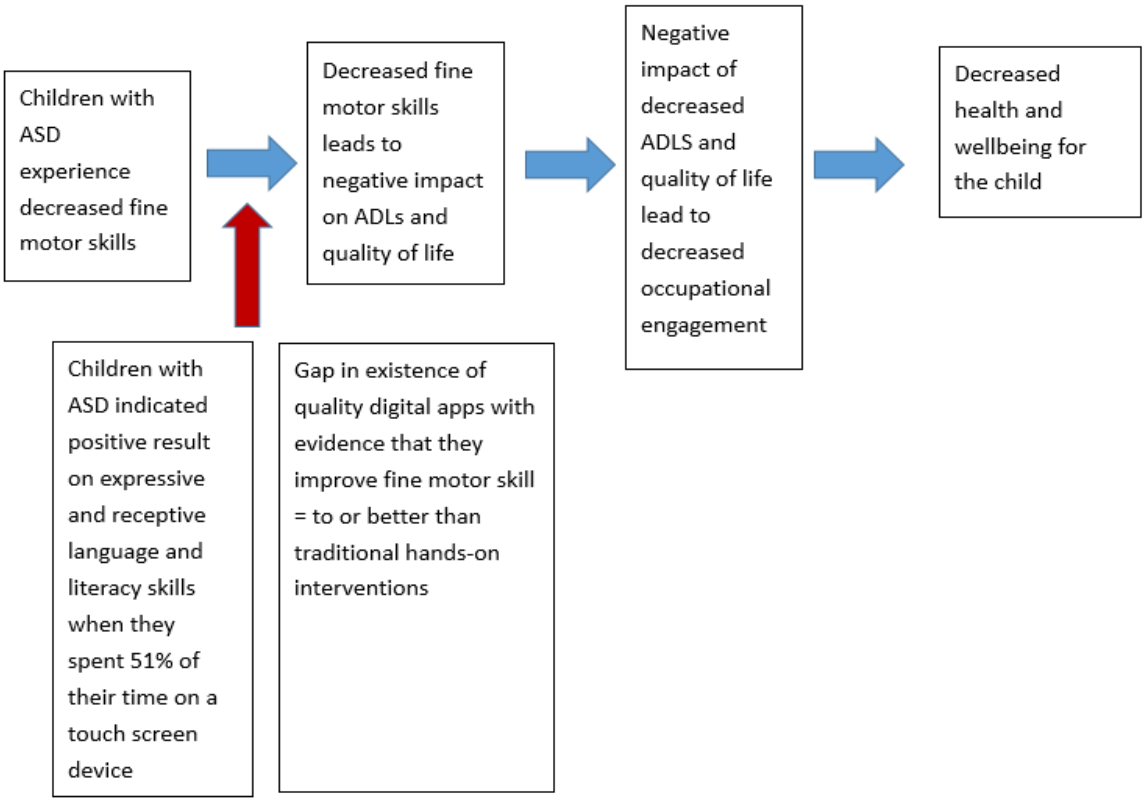
visual rewards and, visual displays to help monitor progress and a competition component to encourage correct answers (King et al., 2017).

Explanatory visual model

During therapy sessions, applications became popular for therapists to use with the client, and children with ASD have positive results on expressive and receptive language and literacy skills when they spent 51% of their learning time in both school and home settings on a touch screen device (Yamkovenko, 2018; King et al., 2013). However, the limitations of applications and the lack of training to those who use the applications for teaching raise concerns that these may not benefit child development, regardless of health status. Other insufficient settings include giving “rewards” for incorrect answers, a lack of visual rewards, visual display, and a competition component (King et al., 2017). In addition, none of the existing applications have been targeted to people with ASD (Jones et al., 2018). These results in continued reduced fine motor skills in children with ASD.

Figure 2.1

Explanatory Visual Model of Identified Problem



Narrative of theoretical or conceptual frameworks

The first theory chosen is the Technology Acceptance Model (TAM). In terms of the limitations of the existing applications, TAM will provide a clear view about significant inclusions of an application to children with ASD. The TAM is a well-known model to examine the use and acceptance of an information system by individual users (Lee et al., 2003) and three key elements in the TAM explained include Perceived Usefulness (PU), Perceived Ease Of Use (PEOU) and behavioral intention (Davis, 1989). PU is referred to the potential user's subjective probability that employs a particular application system that will improve an individual's work or life performance (Davis, 1989; Surendran, 2012).

PEOU is defined as the degree to which individuals believe how simple it is to utilize the technology (Davis, 1989; Surendran, 2012). Between PU and PEOU, and behavioral intention, a sub-key element – attitude acts as a moderator which is directly affected by PU and PEOU and defined as the user evaluation on the technology that includes positive or negative reactions (Zhao et al., 2018). These positive and negative reactions will then influence users' behavioral intention towards the use of the technology (Zhao et al., 2018).

In addition, the Diffusion of Innovation (DOI) (Rogers, 2003) helps in understanding how implementation will take place, what the facilitators and barriers are, and whether the outcome may lead to either a success or failure. The DOI acts as a guide to make it easier for implementation to take place and to help users recognize the facilitators and barriers that may influence the program implementation. This theory recognized the importance of implementation processes of the spread of innovations, acknowledging that various implementation factors and approaches may lead to different outcomes which are suggested to evaluate them when possible (Paina, 2019). According to Rogers (2003), adopters have important perceptions about the features of the innovation, including relative advantage, compatibility, complexity, trialability and observability. In terms of relative advantage, more therapists are using a touch screen device, and this is seen as an effective tool. Regarding compatibility, the existing applications are not competitive due to the lack of tracking system. It was suggested that the applications should include a tracking system which can be monitored, and the task should be more challenging once the goals are achieved. In addition, the existing applications causes issues to prevent therapists to use due to the lack of rewarding system and wrong reward for wrong answers.

An application for children with ASD should be simple and easy to adapt with clear reward system and instructions. Considering another innovation characteristics from the DOI, trialability, the innovation will be ideally free for trial before purchasing any equipment or software. Lastly, with observability, it is important that the adopters can clearly see the benefits of the innovation, such as using applications on a touch screen device will benefit children with ASD in learning.

Questions that guide the search of the literature

The search utilized CINAHL, PubMed and MEDLINE and the search terms employed include autism spectrum disorder OR ASD OR autism; negative impact OR impairment OR deficits; learning OR development OR performance; fine motor skills OR handwriting skills OR hand strength; digital devices OR touch screen technology OR touch screen device OR iPad; fine motor skills OR handwriting skills OR hand strength; cons OR side effect OR negativity OR disadvantage. The inclusion criteria include articles published between 2000 to 2020; peer-reviewed; English publication and age range was limited to 3 to 17 years.

Question 1: Is there evidence that ASD negatively impacts child's developmental skills, especially fine motor skills/handwriting skills?

Dewey et al. (2007) and Memari et al. (2015) found that children with ASD commonly have motor impairment and require more support for learning and daily living due to its deficits. Kruger, et al. (2019) explained that children with more severe ASD will experience greater deficit in motor skills. Kruger, et al. (2019) and Memari et al. (2015) found that there is a significant association between motor skills and participation in

physical activity. Children who actively participate in physical activities tend to have higher motor skills, however most of the children with ASD are inactive and factors that limit their participation in physical activities, such as the lack of positive experiences in exercises, constant filature, emotional deficits, and low self-esteem (Kruger, et al., 2019) and Memari et al., 2015). As a result, this has negatively impacted on participation of children with ASD in physical activities and has led to reduced functional ability in motor skills (Kruger, et al., 2019) and Memari et al., 2015). A result of a study by Green et al. (2009) showed that ASD children with an IQ lower than 70 were more impaired in motor skills than those with IQ higher than 70. It further reported that ASD is a serious impact on children's motor skills that affects their psychological development and social interaction skills and have more negative impacts on their daily lives and performance at home, school, work, and their community (Green et al., 2009; Kruger, et al., 2019; Memari et al., 2015).

Question 2: Is there evidence that fine motor skills are important for child's development?

Fine motor skills are one of the unique and essential foundation skills in developing handwriting and an effective component to develop social skills of children (Alaniz et al., 2015; Dehghan et al., 2017; Seo, 2018). Fine motor skills have a strong association with visual motor skills in children's social competence and maturity (Dehghan et al., 2017). Hence, fine motor skills can be used in conjunction with other effective factors to improve social skills of children who have social deficits (Dehghan et al., 2017). In child development, grip and pinch strength is particularly important for them to perform fine motor tasks (Dehghan et al., 2017). The failure of performing fine motor tasks can

negatively impact on children's occupations including self-care, school, and leisure activities (Dehghan et al., 2017; Seo, 2018). As a result, their self-esteem, confidence, and quality of life are affected due to frustration caused by failure in performing daily tasks or it can be difficult for them to succeed in life like their peers (Dehghan et al., 2017).

Question 3: Is there evidence that children with ASD will benefit from using digital devices such as a touch screen device?

Allen et al. (2016) explained that using applications on a touch screen device can be an easier way for individuals with ASD to adapt to accommodate different learning styles and their current knowledge than face-to-face learning, due to the number of repetitions of material to be learned and practiced, the quantity and type of scaffold to aid learning, and the level of difficulty which can all be adjusted automatically based on the learner's level and response. This study further suggested that game-like applications promote motivation and rehearse two key joint attention skills in children with ASD (Allen et al., 2016). In a study from Cai et al. (2018), it stated that children with ASD can be benefited by appropriate games that target their life skills and a game in one of the applications used in the study allowed the participants who are 9–11-year-old children with ASD to transfer the rules and skills that they have learnt from one game to another. In addition, research studies from Kołakowska et al. (2017) and Stiller et al. (2019) showed that motor control supports social engagement, emotional expression, and cognitive development. One of the effective uses of tablets is video-based modelling, which the users video modelling with another person as a model or video self-modelling (Kołakowska et al., 2017). Using a touch screen device with appropriate applications improves manual dexterity and facilitate learning of

academic content and for children from young age (Butler et al., 2019; Dessoye et al., 2017).

CHAPTER THREE – Overview of Current Approaches and Methods

Introduction

Hamidi et al. (2011) reported that technologies became commonly used in educational and clinical settings in both developed and developing countries, due to the fact that children with and without disabilities benefit from it. Children with disability have demonstrated increased concentration span and improved engagement in class activities using touch screen devices, such as a tablet. This chapter presents an overview of literature on existing methods and approaches for addressing the proposed problem stated in Chapter Two.

Evaluative Summary of Methods

Review of evidence reveals that children with ASD have higher level of fine motor impairment compared to children without disability (Green et al., 2009). Fine motor impairment can also negatively impact other learning areas, such as communication and social interaction skills (Dehghan et al., 2017). As a result, the deficits identified under individuals with ASD then negatively impact on their health and well-being. Touch screen devices have become more popular to be used at school and practice (Sung et al., 2016). However, the existing applications on the mobile device do not provide the maximized support and assistance to users due to the limitations/gaps identified in Chapter Two (King et al., 2017).

Although limited evidence found regarding using a touch screen device on children with ASD, few studies identified the problems by addressing the limitations on some of the existing application. Keywords and terms were used to locate relevant information

include autism, ASD, fine motor, hand strength, dexterity, touch screen device, digital device, tablet, and technology. An iPad has been well-known as a touch screen device, and this will also be used in the search.

Questions that guided the search of the literature included:

1. Is there evidence of efficacy for interventions that successfully improve fine and/or visual motor skills (involved handwriting skills) for children with autism spectrum disorder (ASD)?
2. From hands-on/non-tablet therapy, is there evidence about who benefits most from available handwriting/ fine and visual motor interventions? (specifically to autism).
3. For touch screen devices, is there evidence about who benefits most from available interventions?

Evidence Synthesis

A search of the literature on the search questions listed above was conducted utilizing CINAHL, PubMed, PsychInfo, MEDLINE, OTeeker. The MeSH terms used in the search include non-tablet/hands-on, tablet/iPad/touch screen/digital device/technology, handwriting/fine motor/visual motor, primary school student/school-aged children, autism/ASD/autism spectrum disorder/autistic, effectiveness/succe*. Inclusion criteria included: 1) publication between 2000 to 2020, 2) peer-reviewed articles, 3) age group between child to adolescent, and 4) published in English. Studies such as systematic review, pilot study, narrative review, pre-test/post-test study, and randomized controlled trial were excluded.

Firstly, three studies with different interventions that successfully improve fine and visual motor skills in children with ASD were found and reviewed. In the narrative study from Ceccarelli et al. (2020), the authors completed a comprehensive search and 80% of the studies revealed that fine motor skills were improved in children aged 3–12-year-old with ASD by having average of 45–60 minutes of motor skills training for 6–12 weeks. Participants demonstrated significant positive results in fine motor abilities (fine motor precision and fine motor integration), as tested by Movement Assessment Battery for Children – Second Edition (MABC-2). In addition, Criss (2013) found that children aged 6–11-year-old with ASD displayed improvement in handwriting performance after participating in six 30-minute intervention sessions with live sessions through web camera. Activities in the intervention sessions include using a whiteboard to click and drawing on the screen to complete interactive games and other activities, such as maze or writing. A pilot study also showed that 36 children with the age of 5–12 and ASD displayed positive results in fine motor skills after participating 8-week intervention with engaging in table-top activities, also as tested by MABC-2.

In terms of non-tablet interventions, three studies were also reviewed, and researchers found that children gained improvement with these interventions. However, only one study specifically focused on the population of children with ASD (Carlson et al., 2009). Both studies from Howe et al. (2013) and Kadar et al. (2020) assessed interventions focusing on improving handwriting skills in children in mainstream. Howe et al. (2013) suggested that the Handwriting Club model is a natural intervention that easily fits in school curriculums and can be a short-term intervention to help and improve handwriting

skills in children. On the other hand, Kadar et al. (2020) stated that the results of their study were similar across samples with or without disabilities, hence, the authors suggested any OT intervention with targeted goals such as handwriting can benefit to children in their handwriting performance, regardless of their conditions. The results in a pilot study from Carlson et al. (2013) demonstrated that a specific handwriting program named 'Handwriting Without Tears' has shown improvement in the participant's ability to write the letters utilized in the study, although the sample (N=2) in the study was small. The authors suggested further studies are required.

Lastly, four studies were found and reviewed in available digital tablet-based interventions in improving fine and visual motor skills in children with ASD. Consistently across the studies, researchers found that using digital tablet-based interventions such as an iPad, can not only be a motivating tool for children, but can also improve visual motor integration, cognitive functional and social skills (Axford et al., 2018; Coutinho et al., 2017; Dessoye et al., 2017; Esposito et al., 2017). Three out of four studies focused on children with ASD and special needs (Coutinho et al., 2017; Dessoye et al., 2017; Esposito et al., 2017). A quasi-experimental group pretest-posttest study further showed that participants who used an iPad for 10–12 minutes every day for 10 weeks were able to transfer their visual motor skills from an iPad to pencil and paper (Dessoye et al., 2017).

Although most of the studies with available non-tablet interventions were conducted in children without disabilities, evidence reviewed in this synthesis suggested that both non-tablet and digital tablet-based interventions show effective and positive results in fine and visual motor skills in primary school-aged children. Some studies significantly showed

that digital tablet-use interventions motivate children with disabilities and improve their handwriting skills. However, there is still no particular digital tablet-based intervention just for children with ASD. Overall, an iPad with different applications is the most effective and motivating tool for children, practitioners, and teachers. As mentioned earlier, children with ASD were also able to transfer their visual motor skills to pencil and paper after receiving a block of intervention (Dessoye et al., 2017). The intervention implemented in the study included using handwriting application and visual motor games for 10–12 minutes daily for 10 weeks (Dessoye et al., 2017). Coutinho et al. (2017) suggested that two 40-minute sessions every week for 10 weeks could be effective in improving visual motor skills. In addition, Axford et al. (2018) recommended that using specific iPad application for 30 minutes daily for 9 weeks are effective in improving visual motor skills in children without disabilities. Evidence seems to suggest children without disability are recommended to use the digital tablet-based intervention for longer duration, whereas children with ASD or special needs should use shorter period. However, the digital tablet-based intervention should be implemented with both children with and without disabilities for 9–10-week intervention (Axford et al., 2018; Coutinho et al., 2017; Dessoye et al., 2017; Esposito et al., 2017). Children with and without disabilities are also recommended using specific applications that meet their targeted goals, such as handwriting or visual motor integration skills (Axford et al., 2018; Coutinho et al., 2017; Dessoye et al., 2017; Esposito et al., 2017).

Conclusion

There is evidence supporting the efficacy of tablet-based intervention for fine motor and visual motor skill development in children with ASD, such as increased motivation and visual motor integration skills. However, greater specificity is needed in guidance of digital tablet-use intervention as well as development of an application containing most-effective features for the ASD population

CHAPTER FOUR – Description of the Proposed Program

Introduction

This chapter provides an overview of the survey conducted in this project as a guidance for the application development. The full logic model with details of the program activities, outputs and the goals will also be shared.

Basis of Program

The author's project aims to create an application for use with a tablet device. Existing applications do not have key useful features making use of these less than ideal. This has led to lower motivation to occupational therapy practitioners (OTPs)s to use touch screen devices with children, although it helps their clients. The key elements Perceived Usefulness (PU) and Perceived Ease Of Use (PEOU) from the Technology Acceptance Model (TAM) were applied as guidance in the development of the application and this project.

Practice Scenario

The application entitled, *Finger Up*, was designed to promote improvement of fine motor skill. *Finger Up* consists of fine motor games designed for the learning needs sometimes present for children with autism spectrum disorder (ASD). During the development phase of *Finger Up*, data collection occurred using a Boston University Internal Review Board (IRB) approved survey collecting quantitative and qualitative responses on needs, experiences, and preferences of OTPs. According to the author's survey conducted in this project, more than 80% of the participants have used a touch screen device and this indicates that the participants perceive that there is probability that

using a touch screen device will improve performance in their clients. With a simple layout and easy instruction, the application will lead to positive reaction and behavioral intention on therapists. Analysis of feedback and data was important to determining key features for the construction of *Finger Up*.

Development of Project using Original Survey Outcomes

Participants

The inclusion criteria for the survey are 1) registered OTPs who work in pediatric setting, 2) work in an English-speaking country, and 3) have a caseload with children with ASD.

Data Collection Tools

The survey conducted in the author's project include quantitative and qualitative questions. Quantitative questions include multiple choices, multiple answers, and dichotomous questions. In addition to that, open-end questions were included in the survey exploring participants' perspectives, experiences, and ideas on using application on a touch screen device with children who have a diagnosis of ASD.

Data Collection Procedures

Qualtrics^{XM} software was used to collect survey data and a link to the survey was shared on closed social media groups, email to closed OT groups and word of mouth.

Results

Overall, 82 individuals participated in the survey initially, however 69 OTPs met the inclusion criteria. Sixty-one participants have used touch screen devices in their practice before and at least 40 applications (applications) were listed and addressed that

they have used in the past. The limitations of the existing applications identified include 1) a lack of visual display for monitoring progress, 2) a lack of visual rewards, 3) a lack of sound rewards, 4) a lack of visual effect for wrong answers, 5) a lack of sound effect for wrong answers, 6) busy background and sensitivity settings, and 7) not colorful. More than 50% of the participants usually spent 5–10 minutes in their 1-hour therapy sessions. Eighteen participants personally think that a touch screen device will improve fine motor skills of children with ASD; whereas 26 participants do not think that, and the rest did not give an answer. More than 80% of the participants think that 4–6 games are the most appropriate numbers of the game to be involved in the application. Features that all participants would like to include in the application include 1) simple to use, 2) simple layout, 3) a timer, 4) sounding effect for wrong answer, 5) visual rewards, 6) visual effect, 7) simple instruction, and 8) setting a time limit for each game.

Results from survey

What limitations have you found in the applications you have used? (you may choose more than one answer).

- 27.54% reported other, including option scroll off the screen too quickly; overly visual; the screen is too busy; lack of tactile stimulation; difficult to navigate application for new users; challenges with functionality during screen share; screen sensitivity; no funding for purchasing applications; and do not think that students get the same benefits from online as a physical activity.
- 20.29% reported lack of visual display to monitor progress

- 14.49% reported lack of visual rewards
- 14.49% reported lack of sound rewards
- 11.59% reported lack of visual effect for wrong answers
- 5.8% reported lack of sound effect for wrong answers
- 4.35% reported not many games available
- 1.45% reported not colorful

How long do you use the device with your client during an hour therapy session?

- 69.56% selected 5–10 minutes
- 17.38% selected 10–15 minutes
- 7.26% selected 15–20 minutes
- 5.8% selected 20–30 minutes

What kind of features would you like to include in an application for children with autism spectrum disorder that can benefit their fine motor skills? (You may choose more than one answer).

- 14.49% reported simple to use
- 11.59% reported simple layout
- 10.14% reported a timer
- 10.14% reported sounding effects for incorrect answers (i.e. music, words 'Try again')
- 8.69% reported visual rewards
- 7.25% reported visual effects

- 7.25% reported provide simple instructions
- 5.79% reported set time limit for the game
- 4.35% reported grading system
- 4.35% reported sounding reward (i.e. music, words “Well done!”])
- 4.35% reported set time limit for the session (e.g. the application will only allow the child to play for 15 minutes each time when it’s open)
- 4.35% reported other, including the ability to turn on and off all of the above features to customize for the student, using a stylus to proof promote grasp, opportunity to engage proprioception, visual instructions imbedded in the application and activity to support independent participation, games that work with Stylus pen, requires use of certain pinch patterns, and items stay available until they are chosen and ways to track performance for data collection.
- 2.9% reported character vocalization
- 1.45% reported background music
- 1.45% reported bright color
- 1.45% reported dark color

Two out of 40 applications were not found in either Apple store or Google Play store and another two applications do not have free version. In total, 40 applications were tested and used by a volunteer and the features and limitations of each application were also documented. This further assisted the author and application developer for the application development. The results show that 38 applications were considered as hard to

understand and follow and does not contain visual effect for wrong answers and visual display to help monitor progress.

Discussion

According to the survey results, 4 to 6 games is the choice most participants selected and the preferred duration of using a touch screen device is 5–10 minutes. The application developed in this project will cover all the limitations of existing applications addressed from the survey results, including the lack of sound rewards and visual rewards, visual display for monitoring progress, sound, and visual effect for wrong answers; busy background; not colorful; and sensitivity settings. The survey results further guide the application development to include the features such as a timer, a time limit in each game, easy to use and a simple layout.

Full logic model

The following full logic model is a visual representation that shows how the author's proposed project will work.

Program clients and resources

Children with ASD and OTPs s who use a touch screen device with their clients who have a diagnosis of ASD in practice are the program clients. Resources required in the program include the application with the features addressed in the survey results, a touch screen device and coding for the application.

Program and Theories

There are many applications available in the market and the trend of using applications in therapy sessions becomes popular. However, existing applications have

many limitations that discourage OTPs to continue to use it with their clients, even though it helps them. In addition, there is no application that targets the population of children with ASD. The TAM and Diffusion of Innovation (DOI) models were applied as guidance in the development of the application.

Activities and Outputs

This project aims to create an application, *Finger Up,* that covers the limitations identified from the survey results and can best support children with ASD in developing their fine motor skills. The activities in the intervention plan include OTPs to use *Finger Up* with their clients who have a diagnosis of ASD in a 30-minute therapy session, 5 days a week for 3 months. Training will be provided to OTPs prior to the intervention. The outputs include the number of OTPs who use the application during the therapy sessions, the number of children with ASD who complete all sessions required for 3 months, the number of applications downloaded or purchased, and the total profit made.

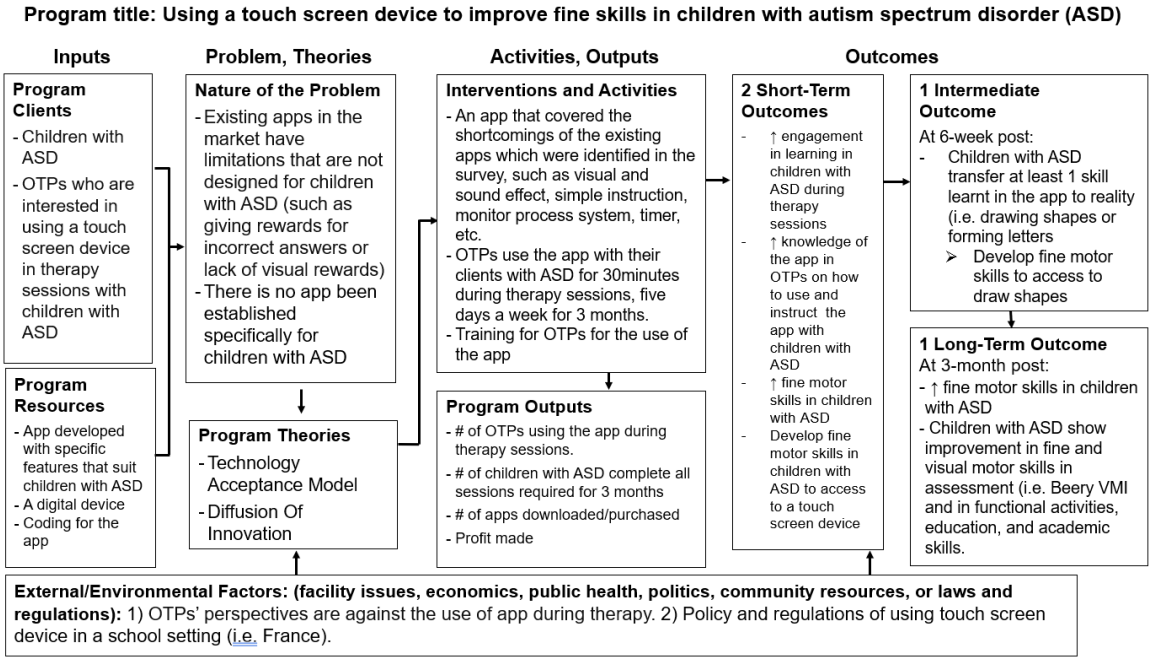
Short, Intermediate and Long-term goals

This program consists of short, intermediate, and long-term goals. Short term goals include demonstrating increased engagement in learning in children with ASD throughout therapy sessions when using *Finger Up*, increased knowledge of *Finger Up* in OTPs on how to navigate it, increased fine motor skills in children with ASD, and developing fine motor skills in children with ASD to access to a touch screen device. Intermediate goal is that children with ASD will be able to transfer at least one skill learnt in *Finger Up* to real life activity, such as drawing a shape, after 6 weeks. The long-term goal of the program is increased fine motor skills in children with ASD and children with ASD show

improvement in fine and visual motor skills in assessment (Movement Assessment Battery of Children – 2nd Edition) and in their occupations, after 3-month intervention.

Figure 4.1

Full Logic Model



Summary

The survey conducted in this project plays a vital role in developing *Finger Up* for children with ASD, with the TAM and DOI models applied. The quantitative and qualitative outcomes from the survey address the gap in the existing applications that shows children with ASD may not get benefits from them and this is the reason why the OTPs are discouraged. These have further helped to guide the application developer in creating *Finger Up* that best support children with ASD.

CHAPTER FIVE – Program Evaluation Research Plan

Introduction

This chapter serves the purpose of presenting an overview of the program and the collaboration between the stakeholders. This chapter additionally highlights the evaluation methods and process for the proposed program and illustrates the simplified logic model.

Program Scenario

Program Details

Finger Up is an application developed in this educational and intervention program for children (aged 5–11) with autism spectrum disorder (ASD) in order to improve their fine motor skills. This application is developed with specific features that are more suitable for children with ASD, and as well as a training for international occupational therapy practitioners (OTPs) (education on how to use *Finger Up* and deliver instruction with their clients during therapy sessions). OTPs are the primary stakeholders who believe *Finger Up* through touch screen devices and are interested in the use of applications/touch screen devices in therapy. The children with ASD are another stakeholder group, as they will directly benefit from this intervention. Additional or potential stakeholders after a certain period of implementation may include the children's caregivers and school staff. School staff may include teachers and teaching assistants who also might be interested in using touch screen devices with their students with ASD.

Program Logistics

Prior to delivering the intervention, three 1-hour training sessions of *Finger Up* are conducted online via Zoom. This training venue allows for all international OTPs to be

able to participate, regardless of pandemic restriction. The author will be the instructor for all the sessions and the author's academic mentor and the application developer will also be involved. The first session will be an introduction with statistics about the effectiveness of touch screen devices for children with special needs, the trend of using touch screen devices in the OT field and the survey results conducted prior to the application development. A week after the first session being delivered, the second session will include the introduction of *Finger Up*, such as different games, features and the sequences of which game should be used first during therapy. The third session will be delivered three weeks after the second session. This allows OTPs to trial *Finger Up* for three weeks. During the third session, OTPs will be able to provide feedback and ask questions through an online meeting. An online survey will be provided to OTPs before and after three training sessions. After the completion of these three training sessions, the program will then be implemented by the OTPs in their countries with their clients. The implementation protocol is a 30-minute session using *Finger Up* 5 days a week for 3 months. From then on, the OTPs will be required to complete a short online survey every week to document the progress or observation of their clients and feedback. An online meeting as a follow-up session will also be conducted every month for 3 months to address questions, feedback, and support. Myself, my academic mentor, and the application developer will be involved in the follow up session every month. After 3 months of the interventional program, an online survey will be conducted for final feedback and a review on *Finger Up*.

Vision for the Program Evaluation Research

The vision of the program evaluation research is to systematically collect and

analyze formative and summative information about this program and deliver a report with results to the primary stakeholders. The findings of the program are important to the future outcomes in the OT field. The author's intention is to reduce the gap between traditional OT (hands on) and the use of touch screen devices in children with ASD and other disabilities. The limitations of the existing applications and the lack of training to those who use the application for teaching raise concerns that technology may not benefit child development, regardless of health status. Insufficient settings include giving "rewards" for incorrect answers; lack of visual rewards, visual display, and competition component; and lack of training to staff who use the applications (King et al., 2017). In addition, none of the existing applications have targeted people with disabilities (Jones et al., 2018). As a result, children with ASD have not shown improvements in fine motor skills associated with the use of a touch screen device. Also, no study has been conducted about the use of touch screen devices in this population. The findings of this program evaluation aim to demonstrate that the shortcomings of the existing applications are covered with targeted features and the fine motor skills in children with ASD will be improved. Hence, more therapists should implement the application in their practice and future study should be conducted in this area.

Overview of important stakeholders

Stakeholders include two levels, micro and meso. Micro stakeholders include the author, the author's academic mentor, the application developer and children with ASD who will use the project's application. The meso stakeholders include OTPs from different organizations and services who will implement *Finger Up* on their clients.

Stakeholder Collaboration

Stakeholder Producers and Consumers

The producer of *Finger Up* for this program will be myself, my partner who is the primary application developer, and my academic mentor. As mentioned in Program Details, international OTPs are the primary stakeholders who will be the consumers who need to learn about the program and implement it in their practice. Children with ASD are those who will benefit from this program. They are potential consumers since they will receive the program from their OTPs.

Stakeholder Engagement

For the producers, myself, my academic mentor, and the application developer will have online meetings via Zoom every week throughout the training sessions and for the 3-month implementation for liaison and adjustments on *Finger Up* based on consumers' feedback.

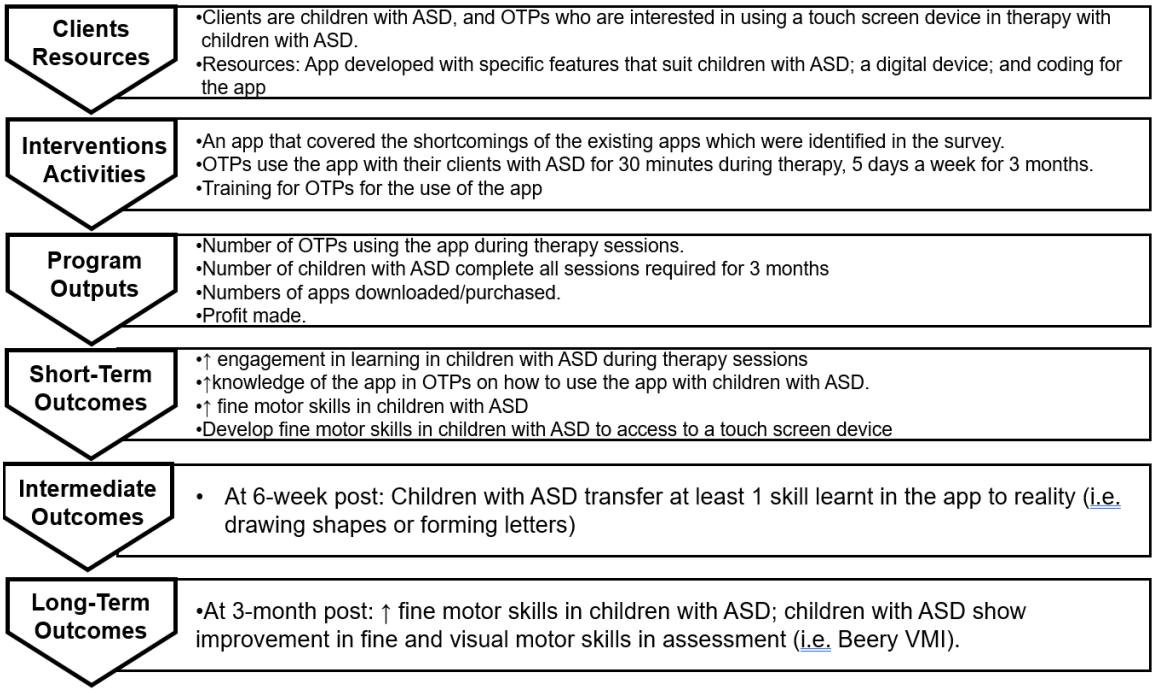
For the consumers, the international OTPs, engagement will come through the online raining sessions and the research itself when they are implementing this program 5 days a week for 3 months with their clients. As mentioned in Program Logistics, I will conduct an online session every month for feedback, questions, and support in case there are technological issues during the intervention phrase. This will also allow me to solve any technical issues and ensure that all consumers including the OTPs, and their clients are benefiting from the program. Overall, it is important for consumers to provide feedback and seek support with *Finger Up* to achieve the vision stated in Vision for the Program Evaluation Research and to ensure consumers are receiving benefits from the program.

Simplified Logic Model

A simplified logic model (see Figure 5.1) will be shown to primary stakeholders during the initial/introduction session. This simplified logic model will provide a clearer and better understanding of how the program flows to the primary stakeholders. It also tells primary stakeholders about the short-term, intermediate, and long-term vision goals and vision of the program. The primary stakeholders will also gain an understanding of the protocol in Intervention Activities on Figure 5.1 and this helps them to follow the protocol when they are implementing the program with their clients.

Figure 5.1

Simplified Logic Model



Confirmatory Meetings

Confirmatory Process

In Program Logistics section, it was explained that three training sessions/meetings will be conducted virtually via Zoom, and virtual meetings will also be held via Zoom every month after for 3 months. The primary stakeholders including international OTPs will be invited in all meetings. The initial session will be the introduction meeting acknowledging the stakeholders participating in this program. The following information will be provided during the introduction session/meeting,

- A concise summary of research about the use of touch screen devices in children with disability.
- A result of the survey conducted for the application development.
- A table that shows comparison of the existing applications and the application developed in this program – showing the limitation that the application in this program covered.
- A simplified program logic model (see Figure 5.1).

Program Evaluation Research Design

This program evaluation research design is comprised of formative and summative program evaluation approaches. It is a single-group design with pre-post summative program evaluation. Quantitative and qualitative data will be collected in both the formative and summative program evaluation portions of this research design.

Initially, the primary stakeholders will be required to complete a short online survey at the beginning and end of the training sessions. This will help the author and application

developer understand their perspectives on the use of touch screen device on children with ASD and whether they have learnt more about *Finger Up* after the training sessions. For example, questions in this particular survey might be 'On a scale 1–5, how confident are you on the use of touch screen devices in children with ASD?', or 'After attending to the training sessions, in what area your clients with ASD may get benefit for (i.e. writing his/her name or do/undo buttons)?'. At the end of each training sessions, the primary stakeholder will also get an opportunity to provide verbal feedback.

Prior to the intervention, the program participants (i.e., OTPs) will also need to complete a pre-test assessment, Movement Assessment Battery for Children-2nd edition (MABC-2), on their clients who will use *Finger Up*. The MABC-2 consists of fine motor and gross motor subtests and only the fine motor subtests will need to be administrated before and after the 3-month intervention. This is to record the pre- and post-result for comparison and progression on child fine motor skills.

During the intervention, when the primary stakeholders deliver the program to their clients, the OTPs will complete a weekly online survey to document what worked well and did not work well for their clients during the sessions as well as any technical issues. During the intervention period, the primary stakeholders will also get a chance to participate in monthly virtual Zoom meetings for feedback and questions. After 3-month intervention, a final online survey will be completed by the primary stakeholders to voice out their perspectives, whether it may be changed, or how effective they have found using *Finger Up* on a touch screen device in practice.

Program Evaluation Research Questions

Table 5.1 (see below) include both qualitative and quantitative program evaluation research questions for each stakeholder group, including: producer–author, application developer and author's academic mentor; primary stakeholders/program participants – OTPs; and program beneficiaries – children with ASD. These questions will be answered through the program evaluation research methodology accompanying launch of this program.

Table 5.1

Program Evaluation Research Questions of *Finger Up*

Stakeholder or Stakeholder Group	**Types of Program Evaluation Research Questions**
Researcher	***Formative:*** Did participants/primary stakeholders feel supported by having follow-up sessions? Following the training sessions, did participants/primary stakeholders understand fully how to implement *Finger Up* on their clients? Did participants/primary stakeholders think the evidence was sufficient for them to understand the effectiveness of the use of touch screen devices? ***Summative:*** How many primary stakeholders downloaded the application and intended to follow the instructions to use the *Finger Up* throughout 3 months? Did the program participants/primary stakeholders report they have increased perceived confidence in using *Finger Up* with their clients in practice?
OTPs actively involved in	***Summative:*** Was the information provided useful for the participants' OT practice? Was the instruction too complicated?

program delivery	Was information provided sufficient for the participants to understand and utilize *Finger Up* in their program? What did they want to change or modify for *Finger Up* developed? Did participants/primary stakeholders feel supported by having follow-up sessions? Did participants/primary stakeholders feel supported by having weekly progress survey during intervention phase? Did participants/primary stakeholders feel supported by having monthly virtual interview during intervention phase? Did they feel supported in relation to technical issues during follow-up sessions? Did they feel supported in relation to technical issues during monthly virtual interview? What did they think about *Finger Up* created according to the result of the survey? ***Summative:*** How many objectives did they learn throughout the training sessions? On a scale 1–10, how well did they understand the content delivered in the training sessions? On a scale 1–10, how likely would they think *Finger Up* would improve their clients' fine motor skills? On a scale 1–10, how confident are they to deliver the program to their clients following the protocol for 3 months? How many potential clients did they think would be able to participate in the program?
Children aged 5–11 with ASD	***Formative:*** Did children with ASD show more engagement in therapy sessions using *Finger Up* in a touch screen device? What did the children like about *Finger Up*? ***Summative:*** To what extent did the protocol of the program improve children with ASD's fine motor skills in terms of self-care tasks? To what extent did the protocol of the program improve the scores of children with ASD in OT assessments after 3 months? To what extent did children with ASD show improvement in their learning after 3 months, such as handwriting skills?

Research Methods

Confidentiality

Based on the regulation of The Institutional Review Board, confidentiality is the priority in order to protect all stakeholder's private information. Prior to each session/meeting, the primary stakeholders will give written consent to producers to participate in the training and follow-up sessions, as well as participate in the program to deliver *Finger Up* to their clients. In addition, clients' caregivers will also be required to give verbal or written consent for their children to participate in the program. Caregivers are not involved in the training sessions since they are not the ones who deliver the program. However, the caregivers will be provided a handout of the program to better understand the protocol used in the therapy sessions with their children during the intervention phase. All sensitive information will be stored in a computer-based software, such as Qualtrics^{XM}. It will also be encrypted, and password protected. The computer/data will be accessible only to the producers, including the author, the author's academic mentor, and application developer. Each child will be given a number for the participation in the program and the primary stakeholders will collect their data throughout the 3-month program using the specific number.

Formative Data Collection Methods

Formative data collection methods include the following,

- Evaluation survey – primary stakeholders will be given a short online survey via Qualtrics for the training evaluation after completing three training sessions. The survey will consist of Yes/No, multiple choice and open-ended questions. A sample

of the survey question will be 'On a scale 1–5, how informative the training sessions were to you, in order to effectively implement *Finger Up* on your clients? (1 represents Not informative at all and 5 represents Very informative)'.

- Progress survey – primary stakeholders will be required to complete an online short survey via Qualtrics every week for 3 months once they finish the training sessions and begin the program with their clients. A sample question will be 'Did you experience any technical issues when using *Finger Up* with your client, such as sound not working, or timer stopping unexpectedly during activities?'. In addition, OTPs will observe their clients, and this should be documented in the survey as well.

Formative Data Management and Analysis Methods

Formative data, including open-ended, close-ended and short-answer data surveys and virtual meetings, will be collected using Qualtrics and Zoom software. Qualtrics can collate written responses from the participants' surveys. Audio in the virtual meeting can be transcribed by Zoom. After generating the qualitative data collected from Qualtrics and Zoom, these transcripts can then be imported into QDA Miner Lite, which is a free computer-assisted software that analyzes qualitative data. In addition, an analytical approach, such as description might be used to analyze all qualitative data collected; this is a useful approach for capturing and evaluating fieldwork observation, as well as data from interviews and focus group (Newcomer & Triplett, 2015). The process of analysis will be checked by my academic mentor to ensure the accuracy of the data. One of the descriptive methods in qualitative data analysis is a matrix, which displays connecting

variables or labels of interest in a table format (Newcomer & Triplett, 2015). This can be used to organize data by type, and they can be used to compare evaluation participants or sites (Newcomer & Triplett, 2015). An example of the matrix is below,

Stakeholder Group	***Perspective on the Program***	***Example quotes***
OTPs	Believe that using touch screen devices are beneficial to children with disability, however not sure how to use *Finger Up* effectively in the program	"I use different applications in practice, but how will this particular application be effective intervention for the children?"

This descriptive approach can also be used during the 3-month intervention period when the primary stakeholders are collecting data from their clients, such as observation.

To analyze quantitative data collected from close-ended survey questions, such as rating-scale questions, software such as Excel will be used. Excel can calculate the descriptive statistics from the quantitative data.

Summative Data Collection Methods

Summative data collection methods with single-group pre-post format include the following,

- Survey for before and after training sessions – OTPs will be provided a pre- and post- training sessions survey to assess how their perspectives changed due to the training sessions. This survey will be administrated online via Qualtrics and will consist of multiple-choice questions and questions with a Likert rating scale. An example of the questions will be 'On a scale 1–5, do you believe that using touch screen devices can promote better learning in children with ASD?'. Ideally, 70

participants will be recruited who completed the survey for the application development before. The independent variable is the three intensive one-hour training session on *Finger Up* of the program. Dependent variables include clinical understanding of the impact of the use of touch screen devices on children with ASD and their perspective on this intervention.

- Pre-test and post-test assessment of clients' fine motor skills – OTPs administer the MABC-2 to clients before and after the intervention. The scores collected will be documented on a spreadsheet via Excel. Independent variables include OTPs using *Finger Up* in therapy sessions with their clients with ASD for 3 months (30 minutes per session, five days a week). Dependent variables include the fine motor skills of children with ASD, such as their scores recorded from their pre- and post-test assessments.

Summative Data Management and Analysis Methods

Firstly, the quantitative data collected from the survey will be collated via Qualtrics. Then, the data will be imported into Excel spreadsheet for analysis. In terms of the pre- and post-test assessment, results will also be imported into Excel spreadsheet and analyzed using descriptive statistical analysis for this quantitative data. For statistical collection and analysis, a software, Statistical Package for the Social Science (Ali & Bhaskar, 2016), can also be utilized to demonstrate improvement of the fine motor skills of children with ASD from pre to post intervention. All summative data will be checked by my academic mentor to reduce any possibility of errors.

Disseminating the Findings of Program Evaluation Research

The Message

OTPs need to have a clear understanding of the use of the featured application developed in this program to help their clients improve fine motor skills. Implementing the program evaluation research and disseminating findings is important to demonstrate the success of the use of touch screen device with a featured application to minimize the gap in the current research field.

The Audience

The primary stakeholders, OTPs, will be the audience who will receive the information about my program and the research findings. As they are involved in the training sessions and implementing the program with their clients, it is important for these primary stakeholders to learn about the findings and gain insight whether *Finger Up* can be used as another therapeutic intervention in practice. The continued development of *Finger Up* also requires primary stakeholders' involvement; hence, they will be the audience to learn about the future development in the application based on the research findings as well.

The Medium

Since the primary stakeholders are the only audience in this program, they will initially be provided with the two-page executive summary of the findings, which may also include graphs, charts and statistics. The primary stakeholders will be provided with an electronic summary of findings and recommendations of the research study by using the killer paragraph. This will be provided after the two-page executive summary is presented.

Thinking further, the next audience could be the council and policy maker. In this case, a technical report would be appropriate which will include more context and details of the methodology of the research study (Grob, 2015).

CHAPTER SIX – Dissemination Plan

Introduction

Dissemination is important in this project to increase the awareness of using a touch screen device in children with autism spectrum disorder (ASD), hence maximize the impact that this project can have in improving the fine motor skills and quality of life in this population. This chapter details a budget plan for dissemination, delivers key messages of this project for the stakeholders and the techniques for delivering the messages.

Project Description

The trend of using applications on a touch screen device in medical sectors continues to rise globally. Children with communication and social difficulties, particularly those with autism spectrum disorder (ASD), often utilize educational and recreational applications at their home and school settings. Recent studies suggested that compared to face-to-face learning, using applications on a touch screen device demonstrated advantages in improving social communication skills and promoting learning in children with ASD (Allen et al., 2016). Using a touch screen device is also easily adapted to accommodate different learning styles and the materials can be used repetitively. However, choosing an appropriate application is important for this population since not many applications target specific skills or provide reinforcement for success (Jones et al., 2018). Recent research reported that no application exists in the market that is targeting children with ASD (Jones et al., 2018). This project aims to develop an application with specific features that will potentially improve the fine motor skills in this population.

Dissemination goals

The main goal of this application, *Finger Up,* is to enhance their fine motor skills and that would transfer the skills in a real environment, such as handwriting tasks at home. This project also aims to promote the use of digital technologies in therapy sessions, particularly for children with ASD who have difficulty concentrating on table-top activities or prefer using digital technologies. The long-term goal of this project is that children with ASD show improvement in fine and visual motor skills in functional activities, education, and/or academic skills. The short-term goals include 1) increasing engagement in learning in children with ASD during therapy sessions; 2) increasing knowledge of *Finger Up* among occupational therapy practitioners (OTPs) on how to use and instruct *Finger Up* with children with autism, and 3) developing fine motor skills in children with ASD who have access to a touch screen device.

Target audiences

The primary audiences for dissemination of this project are OTPs who will use the applications on a touch screen device with their clients in practice. OTPs are the primary stakeholders to implement this intervention in this population. In the future, they can train the caregivers of the children and continue to use *Finger Up* effectively outside of therapy.

The secondary audiences are the children with ASD and their major caregivers. The children with ASD will be exposed to *Finger Up* and the goal is to enhance their fine motor skills through this application. Their caregivers also play an important role in the dissemination of this project as they will potentially also use *Finger Up* with their children in the long term.

Key messages

For primary audiences:

1. More than 80% of the participants in this author's original research survey described in Chapter Four have used a touch screen device with their clients. Some of them think that using it can potentially improve the fine motor skills in children with ASD.
2. Jones et al. (2018) stated that there is no application that targets the population of children with ASD, and the author's original research survey results showed that the majority of the participants did not have a good experience with specifics applications due to their limitations, such as giving positive reinforcement to wrong answers. The application designed in this project, *Finger Up,* will cover the shortcomings of the existing applications. We hope that this provides therapists confidence to continue supporting children with ASD in different learning styles.

For secondary audiences:

1. Current studies suggest that choosing an appropriate application that targets specific skills and provides positive reinforcement for achievement is important for children with ASD (Allen et al., 2016). Using applications on a touch screen device will promote learning and engagement in this population (Yamkovenko, 2018; King et al., 2013).

Sources/messengers

- For primary audiences: The Royal College of OT and the World Federation of Occupational Therapists (WFOT) are great source to spread the message of the

program since OTPs have access to both sites.

- For secondary audiences: Many caregivers of children with disabilities will access the local authority website or community site where they receive information and support. The chairperson of the local authority is a comprehensive resource that delivers the message of the program.

Dissemination activities

To reach the primary audience of clinical- and school-based OTPs, a poster presentation with details of the program components, evidence behind the program and program outcomes will be vital to present at the WFOT Congress. This person-to-person contact will include conversing with other OTPs at the Congress and disseminating necessary information. The poster will be developed and presented by the author of the proposed program. A person-to-person workshop within the local OT community will be established to introduce the use of *Finger Up*. A poster with statistics, research evidence and survey results will be briefly explained during the workshop to share the aim and the idea behind this project. The OTPs within the local area will be invited. In addition, another person-to-person activity such as a guest speaker in an OT academic program will provide a great opportunity to promote the use of *Finger Up*. An overview of the project with statistics and research evidence and demonstration on the *Finger Up* will be shared and during the lecture.

Social media including online OT groups via Royal College of OT or pediatric OT groups via Facebook and LinkedIn will also be used for sharing information of the project. The post with discussion will increase the awareness of *Finger Up* and touch screen device

used in therapy. Multiple online 45-minute workshops will also be delivered via Zoom for international OTPs to learn more about this project and *Finger Up*. This workshop will be arranged once every 2 weeks virtually. Invitation will be posted on Facebook and other social media platforms.

Budget

The major expense for the dissemination activities will be the travel cost to local and overseas WFOT Congress meetings. The entry fee for the WFOT Congress is required and the cost will cover all three days of the Congress. Meals and lodging expenses are required mainly for overseas travel, including the WFOT Congress that is held in France. Rental for a conference room in the local community for the face-to-face workshops will be required. Public transportation costs in local arears for the workshop to promote *Finger Up* are also required. Other budget resources will include printing, supplies and materials for the workshops and the Congress.

Table 6.1 *Dissemination Activities Budget*

Expenses	**Cost**
2022 WFOT Congress (entry fee)	$394
Meals and lodging (including local and overseas)	$1000
Advising/printing (poster/flyers)	$300
Travel (including flights, public transportation, and mileage)	$700
Venue for 1-hour face-to-face workshops	$300
Total:	$2594

All costs are in the United States currency

Evaluation

The dissemination activities will be evaluated through person to person contact and electronic media to determine 1) if *Finger Up* is reaching targeted audiences, 2) if use of *Finger Up* was successful and 3) if the desired outcome occurred. During the poster presentation in the 2022 WFOT Congress, the number of audience members and the number of contact information exchanges for further discussion will be recorded. In order to attract audiences in the Congress, a free trial on *Finger Up* will be provided. During face-to-face workshops and guest lectures in different universities, all attendees will be recorded. These numbers will indicate the success of the dissemination using this method. The number of individuals who share the post or discuss the post will be tracked through Facebook, LinkedIn and Royal College of OT, electronically. With the online 45-minute workshops, numbers of participants for each workshop will be recorded manually, not including those join 5 minutes before or after the workshop sessions. These will be used to analyze the success of the dissemination. Furthermore, to determine the effectiveness for the use of *Finger Up*, feedback from educational sessions will be collected from 10–20 session attendees within year one of the application roll out. Additionally, 6–10 OTPs who have implemented use of *Finger Up* within the first year of roll out will be recruited to provide feedback on its efficacy and student goal achievement when using it.

Conclusion

The goal of this project is to improve fine motor skills in children with ASD through an app with specific features. The purpose of the dissemination plan does not only promote the use of touch screen devices, but also the effectiveness of *Finger Up* in this population.

Hence, the use of *Finger Up* will potentially improve the engagement and success in learning in this population. Different dissemination activities will successfully deliver the message of the program to the primary and secondary audiences identified in this project.

CHAPTER SEVEN – Funding Plan

Introduction

Different resources and equipment are required to develop an application, *Finger Up,* that support children with autism spectrum disorder, such as time, software, and hardware. This chapter presents a detailed budget plan and possible funding options for this project.

Project Description

Use of applications on a touch screen device in medical settings continues to become more popular. Studies report that children with disabilities benefit from using an application in learning (Sung et al., 2016; King et al., 2013). However, existing applications have several limitations that prevent therapists from effectively using them with their clients, including giving "rewards" for incorrect answers; a lack of visual rewards, visual display, or a competition component; and a lack of training for staff who use the applications (King et al., 2017). This frustrates therapists who stop using applications on a touch screen device that could potentially assist children learning disability. Another study also stated that no existing applications have specifically targeted children with disabilities or autism spectrum disorder (ASD) (Jones et al., 2018). The proposed program in this project is to develop an application, *Finger Up,* with specific features for therapists to use to assist the children with ASD in fine motor skills in therapy sessions.

Available local resources

Available local resources include the author's partner who is the major application developer, potential occupational therapy practitioners (OTPs)who can trial *Finger Up* and

children and their parents who volunteer for trials. The author's academic mentor, potentials OTPs and their clients will be given the access to *Finger Up* so they can use it during their therapy sessions. Instructions on how to navigate *Finger Up* will also be provided to OTPs who volunteer. The trial will use *Finger Up* for once or few times a week, depending on the time that volunteers are willing to spend on.

Needed resources: Budget

For the first year of the program, at least three months are required for the development of *Finger Up*. Within the creation of the application, the main duty of the author is to design the application layout and create animation for the application. Whereas the application developer's duties include coding for the application and as well as designing the layout. The author and the application developer will spend time after work and as well as spend time on the weekend for the application development. These extra hours are calculated based on the current salary rate without taxes of both the author and the application developer.

In addition to the salary expenses for the author and the application developer, there are also expenses for supplies and equipment. The major supplies for the program are two computers for both the author and the application developer which costs $7000 in total. Rights to Adobe After Effect will also be required for drawing and producing the animation, which will be necessary for the creation and maintenance of the program for the first two years. This will cost $33 for lifetime use. Other equipment required for the program is the touch screen devices for using *Finger Up*, such as a phone and a tablet. However, the author currently owns the phone, the tablet, two computers and Adobe After

Effect, therefore these will not be an additional cost for the program.

Another expense is the advertisement expenses. One of the advertisements is on Royal College of OT where any continuing development courses or opportunities can be advertised. Its membership is $32.94 per year. Free advertisement platforms include the Facebook OT group page. To make *Finger Up* available in the market, there is cost for the submission of the application in Apple Store ($99/year) and Google Store ($25 one-off). In addition, the budget for dissemination includes the entry fee for the World Federation of Occupational Therapists (WFOT) Congress, international and national travelling costs, living expenses during the Congress, venue for the face-to-face workshop, and printing for posters or flyers.

Free recourses include volunteers who will trial *Finger Up* and give feedback to the author and the application developer before launching the application. Communication and evaluation between the author, the application developer, volunteers, and users all take place on free platforms including, WhatsApp, Zoom, and Gmail.

Table 7.1. *Budget Description*

Budget items	**1st year**	**2nd year**	**Justification**
Salary (Personnel)	$43/hour (time used for the application development) Approximate 20 hours per month = $860	Application maintenance Approximate 4 hours per month = $172	The author and the application developer will need to spend time for the creation of the program which is to develop the *Finger Up*. Twenty hours each month for 3 months are required to develop *Finger Up* and after it is developed, 4 hours for every month are required for maintenance on the application. Once *Finger Up* is launched and users start purchasing, the salary will be covered from the payment the users pay on Apple and Google Stores. The benefit will include the children with ASD gaining improvement in their fine motor skills and assisting OTPs in implementing tablet-based intervention in their practice.
Consultants (application developer)	$75/hour (time used for the application development) Approximate 30 hours per month = $2250	Application maintenance Approximate 4 hours per month = $300	
Supplies	Adobe After Effects $33 (one-off and already owned) or Computer x2 = $7000 (already owned) Internet: $25/month	 Internet: $25/month	All supplies have been purchased and no cost will be associated with this in the project.

Equipment	Tablet $299 (already owned) Phone $599 (already owned)		Required equipment includes touch screen devices that trialing *Finger Up* and instructing the application to the users.
Advertisement expenses	Royal College of OT $32.94/year Facebook (free)	Royal College of OT $32.94/year Facebook (free)	In the United Kingdom (UK), the majority OTPs will be a member under Royal College of OT. In this platform, OTPs are allowed to advertise continued performance development program or any training opportunities/materials. Therefore, it will be a great platform to advertise *Finger Up*. In addition, there is a no cost platform for advertisement, which is Facebook OT page.
Submitting the *Finger Up* to the Apple store and Google Play	Apple store $99/year Google Play store $25 (one-off)	Apple store $99/year	In order to make *Finger Up* available in the market, subscription to different providers is required and costed. Apple store has a standard fee that costs every year for *Finger Up* being available in the store. Google Play store has a one-off fee.
Volunteers for trialing *Finger Up*	Free	Free	Several OTPs and parents agreed to be volunteers to trial *Finger Up* before it is launched on the stores. This can provide feedback for the author and the application developer.

Communication	Gmail (free) WhatsApp (free) Zoom (45minutes free)	Gmail (free) WhatsApp (free) Zoom (45minutes free)	Communication will be through emails, Zoom and WhatsApp for texting and virtual meetings between the author and the potential users. This is for instructions and training on how to use *Finger Up*, provide support for the users and for feedback.
Evaluation			Evaluation will be through digital word document and through virtual meetings to compare results of before and after intervention with the potential users. No particular expense will be necessary.
Dissemination expense	$2594	$1500	Dissemination for the first year includes the WFOT Congress, travelling, meals and lodging, advertisement, and venue. For the second year, cost will be reduced as it does not include the Congress and expense for international travel.
Total expense per month	$4025.16 for 3 months $915.16 (after 3 months application development)	$632.995	
Total expense per year	$20311.89	$7,595.94	

All cost is in the United States (US) currency.

Potential funding sources

With the budget listed previously, there are several funding sources available for this project which are addressed in Table 7.2.

Table 7.2 *Potential Funding Sources*

Boston University (BU) College of Health & Rehabilitation Sciences: Sargent College	This fund supports research, teaching and professional development. Current BU students, postdoctoral fellows, lecturers, tenure-track, and clinical faculty are eligible for proposals contributing to the college's mission of teaching excellence, research innovation, and trans-disciplinary collaboration. Award ranges from $5000 to $8000.
BU Women's Guild Awards	This fund supports women from all Boston University graduate programs with a certain amount of scholarship. Eligible criteria includes women aged 30 and over with two letters of recommendations (one of them must be from a BU faculty member or online course instructor). Award ranges from $500 to $2000.
BU Women's Council Scholarship	This fund supports all graduate students regardless of age with a scholarship. Award ranges from $1000 to $5000.
Agency for Healthcare Research Grant P01: Research Program Project	This fund supports research that improves the safety and quality of the health care system.
BU Digital learning incubator grants	This funding promotes the use of technology and supports experimentation through project funding and program development. This funding will need to be applied with the help of the author's academic mentor.
U.S. Department of Education Office of Special Education Programs – Technical Assistance and Dissemination to Improve Services and Results for Children with Disability Grant	This funding promotes academic achievement and improves outcomes in children with disabilities by providing technical assistance, supporting model demonstration projects, disseminating useful information, and implementing activities that are supported by scientifically based research. The estimated award for this competition is $5,400,000.

Organization For Autism Research – Graduate research grant competition	Students who are doctoral candidates or post-doctoral students are eligible to receive $2000 grants for conducting autism research. International students and students outside the US can apply.
Autism Speaks - Postdoctoral fellowship	This funding is dedicated to promoting solutions for the needs of individuals with autism and their caregivers throughout their lives. US and non-US citizen with master or doctoral degree are eligible for this funding. An $11,000 annual allowance is the award of this fellowship grant.

Conclusion

In conclusion, the proposed project includes different budget items that can be expensive. However, there are several funding options available. Some of the budget items are already owned. In addition, the main communication platform between the authors, the application developer and all volunteers and future potential users will be free of charge.

CHAPTER EIGHT – Conclusion

Review of the problem

Autism spectrum disorder (ASD) is a neurological and lifelong developmental disorder characterized by deficits in social communication and the presence of limited interests and repetitive behaviors (Hodges et al., 2020). Individuals with ASD have difficulties with their social communication, self-regulation, concentration and attention, and motor skills. In addition, nearly 90% of the children with ASD have severe fine motor impairment that negatively impacts on their handwriting and self-care tasks (Bhat, 2020). Most of these individuals require support in performing their occupations (self-care, productivity, and leisure) throughout their lives due to its deficits. Occupational therapy practitioners (OTPs) play a vital role in working with children who has a diagnosis of ASD. Digital devices such as a touch screen device is increasingly used in occupational therapy (OT) intervention when working with this population to help individuals with ASD to manage self-care, sensory issues, and social engagement (Domínguez-Lucio et al., 2022). However, limitations of the existing applications such as busy background, hard to follow, and wrong rewards have misled the children with ASD when they are using them. As a result, this has discouraged OTPs to continue to use applications on digital devices although they help their clients.

Review of the program description

Digital devices enable improved developmental sills, enhances motivation in learning and improves the concentration an attention of children with ASD, however there are many barriers listed earlier keeping OTPs from using digital devices with their clients

(Axford et al., 2018; Coutinho et al., 2017; Dessoye et al., 2017; Esposito et al., 2017). Finger Up has been developed in this project, using applications on a digital device as intervention during therapy sessions to enhance the fine motor skills of children with autism spectrum disorder (ASD), with consideration based on the evidence regarding the advantages of technology use in individuals with disability and the results of the author's original survey carried out in this project. Finger Up with specific features supports children with ASD in developing their fine motor skills and it also covers the limitations of the existing applications. OTPs will implement the program using Finger Up with their clients in a 30-minute therapy session, 5 days a week for 3 months. The major goal of this project with using Finger Up is to enhance the fine motor skills of children with ASD and transferring the skills into real life activities.

Review of guiding theory and evidence foundation

The Technology Acceptance Model (TAM) and the Diffusion of Innovations (DOI) theory guided the development and implementation of all phases of Finger Up in this project. Three key elements including Perceived Usefulness (PU), Perceived Ease Of Use (PEOU) and behavioral intention, in the TAM informs that it is higher chance of users employing a specific application system when it is easy and improves an individual's work or life performance. In addition, DOI theory further emphasizes the importance of conveying an innovation's perceived attributes of relative change, complexity, compatibility, observability and trialability features in influencing potential users' decision to embrace it. Finger Up, therefore, designed to focus on these elements and attributes from both TAM and DOI theories.

A search of the evidence-based literature informed that technology such a touch screen device benefits children with ASD in promoting their independence, expanding their communication skills, and increasing their social interactions with others (Allen et al., 2016; Cai et al., 2018; Kołakowska et al., 2017; Stiller et al., 2019). However, research studies found that the existing applications consists of a variety of limitations that have prevented therapists to continue to use them with their clients, such as the lack of the visual and sound rewards, busy background, complicated to use or wrong reinforcement for wrong answers (King et al., 2017). An additional research study from Jones et al. (2018) stated that none of these existing applications are purposely created for children with ASD. Hence, this program was developed to address the gap in the evidence-based literature regarding benefits, barriers, and adoption of using applications through a touch screen device in OT.

Key findings

Results of survey

A survey was conducted prior to the application development in this project and 69 OTPs participants who met the inclusion criteria revealed that the limitations of the existing apps identified include 1) the lack of visual display for monitoring progress (n=14), 2) the lack of visual rewards (n=10), 3) the lack of sound reward (n=10), 4) the lack of visual effect for wrong answers (n=8), 5) the lack of sound effect for wrong answers (n=4), 6) busy background and sensitivity settings (n=19), 7) not colorful (n=1). The survey results also found that the major features that OTPs believe that it would benefit the children with ASD when using Finger Up include 1) simple to use (n=10), 2) simple layout (n=8), 3) a timer (n=7), 4) sounding effects for wrong answers (n=7), 5) visual reward (n=6), 6) visual

effect (n=5), 7) with simple instruction (n=5), and 8) setting a time limit for each game (n=4). This survey result guided the author in developing Finger Up, which is an application that covers the limitation addressed above and the features recommended by the participants.

Review dissemination plan

Chapter Six Dissemination includes presentations at the 2022 World Federation of Occupational Therapists Congress, travelling expense, advertisement, and venue for face-to-face workshops. Dissemination activities target the goal of promoting the use of technology in OT and the effectiveness of Finger Up in children with ASD.

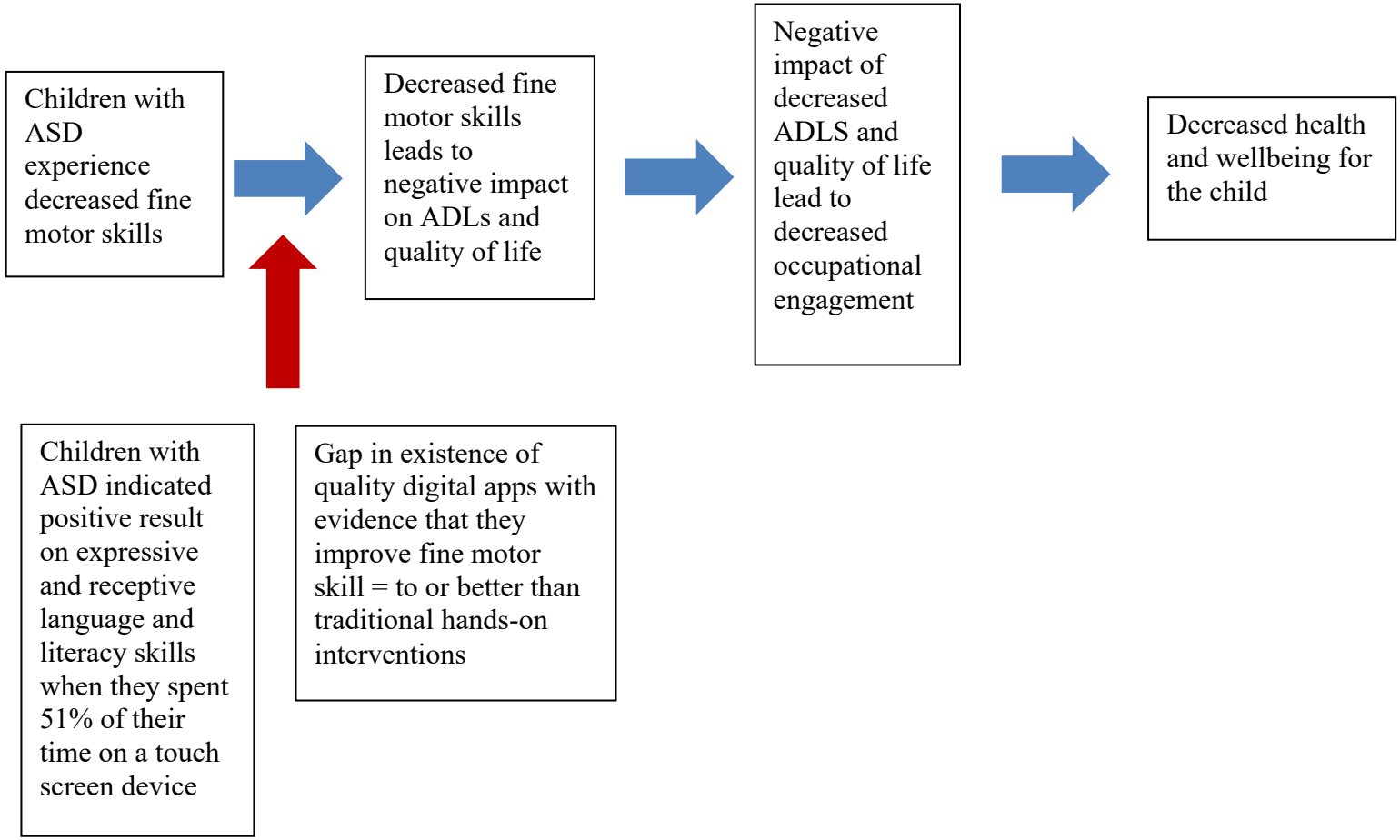
Review funding plan

Chapter Seven presented a detailed budget plan of expenses associated with program planning and implementation. Expenses include consultation fee with application developer, suppliers and equipment/software, advertisement, publication of the application and dissemination expenses. Year one expenses are $ 78981.96, while year two expenses totaled $73772.04, to ensure that the program is conducted professionally and sustainably.

Conclusion

Fine motor skills are particularly important in children development in order to effectively perform daily activities and successfully participate in their school environment (Bhat, 2020). Multiple research studies found that technology use is a power tool to encourage children with ASD in learning and participating in their occupations (Axford et al., 2018; Coutinho et al., 2017; Dessoye et al., 2017; Esposito et al., 2017).

APPENDIX A – Overview of *Finger Up*



APPENDIX B – Invitation for online survey

Consent Form: **Recruitment Post for online survey**
Principal Investigator: Hoi Ki Kan (Kelly)
Version Date: May 29, 2020

For Social Media-Direct Link to Survey

In Search Of: The association between touch screen device and fine motor skills of children with autism spectrum disorder

Hello,
My name is Kelly Kan and I am a student from Boston University. You are invited to participate in this online survey on the association between touch screen device and the fine motor skills of children with autism spectrum disorder. The purpose of this survey is to gather opinions and recommendations on experiences of using applications on touch screen devices (i.e. tablet, phone). The results of this survey can assist for application development for the population of children with autism spectrum disorder and successful future use of touch screen device as a service delivery model. This survey is completely voluntary, and you may refuse to exit the survey at any time. The survey requires 10–20 minutes and no personal information will be obtained in this survey and the information/option you provided are completely confidential.

Potential risks:
- Some of the questions in the survey might be personal and ad to negative emotions, such as sadness. However, you have rights to exit the survey whenever you wish.

- Any information shared on the internet can be intercepted, although materials will be password protected, as is Qualtrics software in an effort to protect this information.
    - We are minimizing this risk in the following ways: using a trustworthy, reliable server, Qualtrics. Data is anonymous – or – All identifying information is removed if appeared. Data collected from the survey will be stored electronically in a passcoded format through the Qualtrics server and will only be viewed by principal and co-investigator (faulty advisor).

If you have questions about your rights as a research participant, or if you have any complaints or concerns and want to speak with someone independent of the research team, you may contact the Boston University Charles River Campus IRB at 617-358-6115; co-investigator (faulty advisory), Cynthia Abbott-Gaffney at 609-706-9041 or abbottgaffney@bu.edu; or myself at kellykan@bu.edu.

Please let me know if I can answer additional questions for you. Your participation is greatly appreciated. Please click consent if you wish to continue this online survey.

For Social Media-Form to add email address to receive survey via email

Email to Potential Participant

Subject Line: In Search Of: The association between touch screen device and fine motor skills of children with autism spectrum disorder

Hello,

My name is Kelly Kan and I am a student from Boston University. You are invited to participate in this online survey on the association between touch screen device and the fine motor skills of children with autism spectrum disorder. The purpose of this survey is to gather opinions and recommendations on experiences of using applications on touch screen devices (i.e. tablet, phone). The results of this survey can assist for application development for the population of children with autism spectrum disorder and successful future use of touch screen device as a service delivery model. This survey is completely voluntary, and you may refuse to exit the survey at any time. The survey requires 10–20 minutes and no personal information will be obtained in this survey and the information/option you provided are completely confidential.

Potential risks:

- Some of the questions in the survey might be personal and ad to negative emotions, such as sadness. However, you have rights to exit the survey whenever you wish.

- Any information shared on the internet can be intercepted, although materials will be password protected, as is Qualtrics software in an effort to protect this information.
    - We are minimizing this risk in the following ways: using a trustworthy, reliable server, Qualtrics. Data is anonymous – or – All identifying information is removed if appeared. Data collected from the survey will be stored electronically in a passcoded format through the Qualtrics server and will only be viewed by principal and co-investigator (faulty advisor).

If you have questions about your rights as a research participant, or if you have any complaints or concerns and want to speak with someone independent of the research team, you may contact the Boston University Charles River Campus IRB at 617-358-6115; co-investigator (faulty advisory), Cynthia Abbott-Gaffney at 609-706-9041 or abbottgaffney@bu.edu; or myself at kellykan@bu.edu.

Please let me know if I can answer additional questions for you. Your participation is greatly appreciated. Please click the link below to begin the survey.
https://bostonu.qualtrics.com/jfe/form/SV_8tUw6xPm3wBpsK9

Kind regards,
Hoi Ki (Kelly) Kan (Principal Investigator), OTR (Australia, UK)

Boston University
Boston, MA 02215
United States

APPENDIX C – Online Survey

In Search Of: The association between touch screen device and fine motor skills of children with autism spectrum disorder

Hello,

My name is Kelly Kan and I am a student from Boston University. You are invited to participate in this online survey on the association between touch screen device and the fine motor skills of children with autism spectrum disorder. The purpose of this survey is to gather opinions and recommendations on experiences of using applications on touch screen devices (i.e. tablet, phone). The results of this survey can assist for application development for the population of children with autism spectrum disorder and successful future use of touch screen device as a service delivery model. This survey is completely voluntary, and you may refuse to exit the survey at any time. The survey requires 10–20 minutes and no personal information will be obtained in this survey and the information/option you provided are completely confidential.

Potential risks:
1. Some of the questions in the survey might be personal and ad to negative emotions, such as sadness.
However, you have rights to exit the survey whenever you wish.

2. Any information shared on the internet can be intercepted, although materials will be password protected, as is Qualtrics software in an effort to protect this information. We are minimizing this risk in the following ways: using a trustworthy, reliable server, Qualtrics. Data is anonymous – or – All identifying information is removed if appeared. Data collected from the survey will be stored electronically in a passcoded format through the Qualtrics server and will only be viewed by principal and co-investigator (faulty advisor).

If you have questions about your rights as a research participant, or if you have any complaints or concerns and want to speak with someone independent of the research team, you may contact the Boston University Charles River Campus IRB at 617-358-6115; co-investigator (faulty advisory), Cynthia Abbott-Gaffney at 609-706-9041 or abbottgaffney@bu.edu; or myself at kellykan@bu.edu.

Please let me know if I can answer additional questions for you. Your participation is greatly appreciated.

By selecting "I agree", you are consenting the conditions described above.

- *I agree*
- *I disagree*

1. Are you a registered Occupational Therapist?
   Y/N

2. In what city/province/state and country do you practice?
   Y/N

3. Are you working in pediatric settings, including school-based, private and public hospitals, private practice?
   Y/N
   If not, please specify_____

4. Is your main caseload the children with Autism Spectrum Disorder?
   Y/N

5. Have you used any touch screen devices (i.e. tablets, phones) in your practice?
   If yes, please answer 5a, 5b & 5c. If no, please answer 5d.

   5a. If you have used a touch screen device in your practice before, which applications have you used before? Please list all applications you have used.

   _____

   5b. What limitations have you found in the applications you have used? (you may choose more than one answer)
   - Lack of sound reward
   - Lack of visual reward
   - Not many games available
   - Lack of visual display to help monitor progress
   - Lack of sound effect for wrong answer
   - Lack of visual effect for wrong answer
   - Not colorful
   - Other (please describe)

     _____

   5c. How long do you use the device with your client during an hour therapy session?
   - 5 –10 mins
   - 10 –15 mins
   - 15 –20 mins
   - 20 – 30 mins
   - More than 30 mins

   5d. Although you have not used it in your practice before, have you heard of any applications that your colleagues or any OTs you know use?
   Y/N
   If yes, please list all applications you have heard _____

6. Do you personally think that using a touch screen device will improve the fine motor skills of children with autism spectrum disorder?
   Y/N

7. What kind of features would you like to include in an application for children with autism spectrum disorder that can benefit their fine motor skills?
   (Please tick those ones you would like to include and you may choose more than one answer)

Visual	Bright color	
	Dark color	
	Character vocalization	
	Visual effects	
	Visual reward	
Auditory	Background music	
	Sounding reward (i.e. music, words [Well done!])	
	Sounding effects for incorrect answers (i.e. music, words [Try again.])	
	Provide simple instructions	
Others	Simple to use	
	Simple layout	
	Grading system	
	A timer	
	Set time limit for the game	
	Set time limit for the session (e.g. the app will only allow the child to play for 15 minutes each time when it's open)	

You may write your comments or suggestions in regards to the features below:

_____

8. How many games do you think it should be included in an application in order to encourage the child to use?

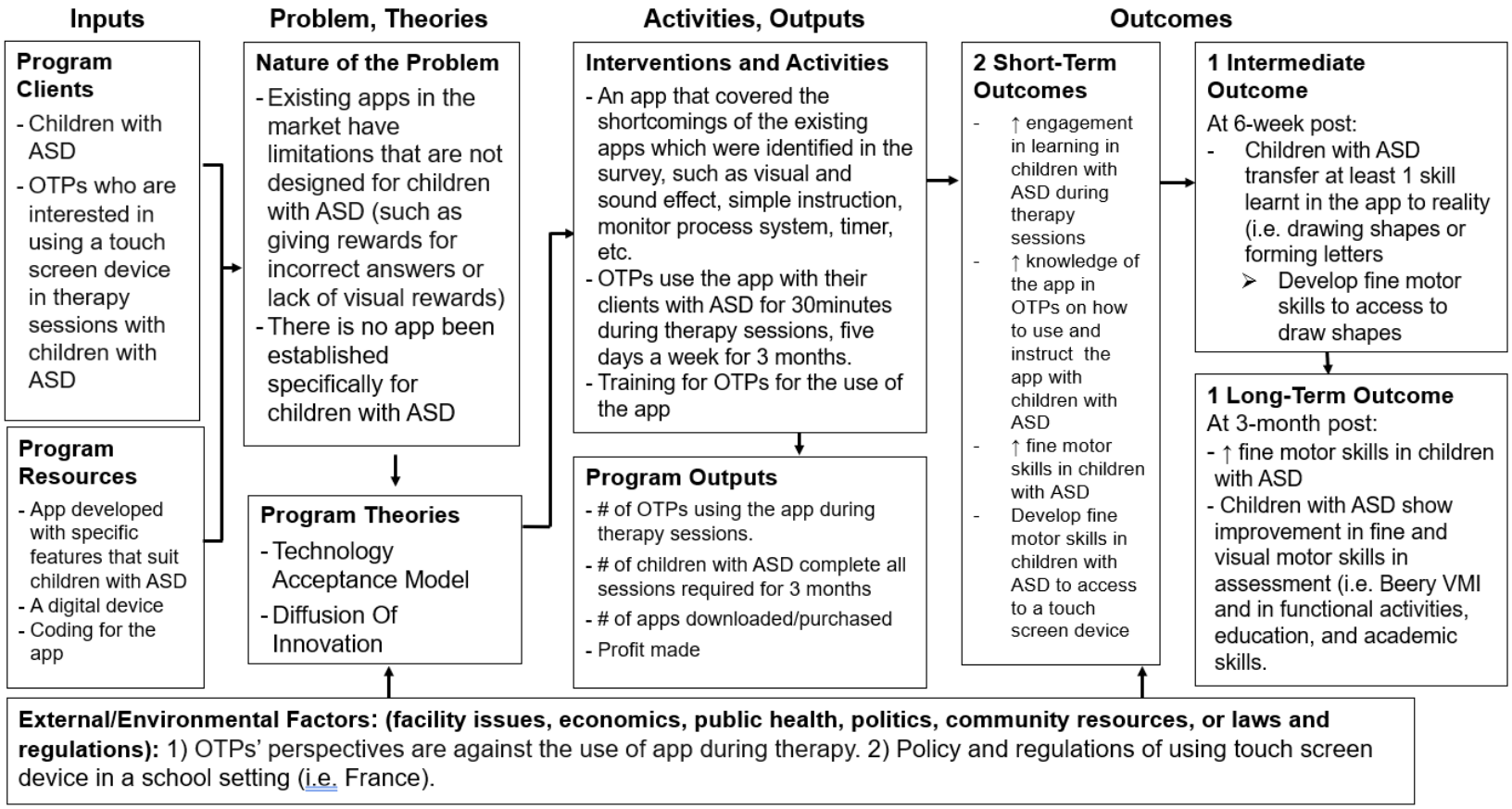
   - 1–3
   - 4–6
   - 7–9
   - More than 10

9. What sort of games do you think should be included in the application in order to improve the fine motor skills of children with autism spectrum disorder? (you may choose more than one answer)
   - Matching cards (when they can use their index finger)
   - Finger tapping games (when they have to follow which fingers were with lights on, and they have to tap with their fingers)
   - Pinching (when they have to use index and middle fingers to pinch an object occurs on the screen)
   - Tracing and writing letters
   - Tracing and drawing shapes
   - Jumping dolphins (a game that requires them to use two fingers to drag and release to make the dolphin jump and catch reward)
   - Running/swimming race (requires them to use two fingers to tap continuously to make the character run/swim)

You may write your comments or suggestions in regards to the features below:
_____

APPENDIX D – Logic Model

Program title: Using a touch screen device to improve fine skills in children with autism spectrum disorder (ASD)



APPENDIX E – Survey Result & Overview of *Finger Up*

Summary of the survey results

Overall, 82 individuals participated in the survey initially, however only 69 Occupational Therapy Practitioners (OTPs) met the inclusion criteria, including being registered OTPs, working in an English-speaking country (Great Britain, the United States, Canada, Australia and New Zealand), working in pediatric setting and have children with autism spectrum disorder (ASD) in their caseload. Sixty-one participants have used touch screen devices in their practice before and at least 40 applications were listed and addressed that they have used. The limitations of the existing applications identified include the lack of sound reward and visual rewards, visual display for monitoring progress, sound, and visual effect for wrong answers; busy background; not colorful; and sensitivity settings. Most of the participants used 5–10 minutes in their 1-hour therapy sessions and 18 participants do personally think that a touch screen device will improve fine motor skills of children with ASD. Whereas 26 participants do not think that, and the rest did not give an answer. The majority of the participants think that 4–6 games are the most appropriate numbers of the game to be involved in the application. The participants would also like the application developed in this project to be simple to use, have simple layout, a timer, visual reward, visual effects, with simple instruction, setting a time limit for each game, grading system, and sounding effect.

Forty applications were tested and used by a volunteer and the features and limitations of each application were also documented. This further assisted the author and application developer for the application development. The results show that more than 20

games were considered as hard to understand and follow and does not contain visual effect for wrong answers and visual display to help monitor progress.

Overview of *Finger Up*

Finger Up is an application developed as an intervention in this project and it consists of 4 games, including memory card game, pinching, drag and match the shapes, and join the dots. According to the survey conducted for the application development, *Finger Up* has a white color background in each game while the objects in the games have a contrasted color, such as red, orange, or green. This way is to keep the application simple and does not have too much visual stimuli. In each game, there is a time limit and scores for tracking. For each correct and successful answer received from the user, a positive reinforcing sound reward is activated. On the other hand, when an incorrect or unsuccessful touch and answer, a negative reinforcing sound effect will be activated. Each game will take around 1–3 minutes which all games in total can take up to 10 minutes for use. In addition, the users can select the same game again after their first attempt.

APPENDIX F – Executive Summary

USING APPLICATIONS ON A DIGITAL DEVICE AS INTERVENTION DURING THERAPY SESSIONS TO ENHANCE THE FINE MOTOR SKILLS OF CHILDREN WITH AUTISM SPECTRUM DISORDER (ASD)

Background

Using applications on a digital device as intervention during therapy sessions to enhance the fine motor skills of children with autism spectrum disorder (ASD), seeks to address many of the shortcomings that exist in current applications in the market. As a result, the program aims to create an application, Finger Up, which will include features that best support children with ASD in learning. This executive summary provides an overview of the proposed program, evidence of the trends and benefits of digital devices for children with ASD and recommendations.

Project overview

Using applications on a digital device as intervention during therapy sessions to enhance the fine motor skills of children with ASD is an educational and interventional program facilitated by occupational therapy practitioners (OTPs) in therapy sessions with their 5- to 11-year-old clients who have a diagnosis of ASD. The primary stakeholders, OTPs, will receive three 1-hour virtual training sessions for an introduction to the application and for technical support. These training sessions will be conducted by the author, the author's academic mentor and application developer. The training will focus on the evidence behind the program, trialing the games, and providing example on an agenda of using Finger Up in a therapy session. After the training sessions, the OTPs will use

Finger Up in a 30-minute therapy session, five days a week for three months. Throughout three months of intervention, the client and the games used in the application are required to remain the same. In addition, monthly feedback and question and answer sessions will be conducted virtually with the primary stakeholders throughout the intervention phase. The major goal of the program includes improving the fine motor skills in children with ASD and in the long term, these skills learned will be able to transfer in a real environment, such as handwriting tasks. It also aims to increase the awareness of the use of technology for children with ASD and OTPs will develop the knowledge in the use of digital devices in practice.

Key findings

Fine motor skills are the foundation for children development of many other important skills in the future, such as handwriting and self-care tasks (Kim et al., 2018). Good fine motor skills are vital, being one of four main predictors of early academic success (Mithyantha et al., 2017). The deficit of fine motor skills is caused by developmental delay which is a condition with genetic and structural brain abnormalities, such as ASD (Mithyantha et al., 2017). Children with ASD commonly have motor impairment and lower level of fine motor skills (Dewey et al., 2007); Memari et al., 2015). Due to these deficits, children with ASD require more support for learning and daily living (Memari et al., 2015). With the impacts addressed, research studies found that technology use increases the occupational performance and participation in individuals with disability (Akyurek et al., 2017).

Technology is very important in today's dynamic world as it helps in accessing food, healthcare, socialization, and productivity (Valencia et al., 2019). Individuals with ASD demonstrates increased engagement and tend to enjoy themselves when interacting with digital devices as these interactions provide them a safe and trustworthy environment (Valencia et al., 2019). Several studies also outline using a touch screen device motivates children with disability in learning and improves their visual motor integration, cognitive functional and social skills (Axford et al., 2018; Coutinho et al., 2017; Dessoye et al., 2017; Esposito et al., 2017). However, the existing applications have many limitations, such as the lack of visual reward, wrong visual and sound effect for wrong answers, misleading those children with ASD when are using it (Jones et al., 2018). In addition, none of the existing application targets the population of children with ASD in the current market. Hence, this has demotivated OTPs using application on a touch screen device in practice, even though it helps their clients (Jones et al., 2018). Jones et al., 2018 stated that an application with appropriate games, features and skills are important for children with ASD. Finger Up was developed according to the author's original survey conducted in this project which will cover the limitations identified earlier. Therefore, Finger Up will not only promote learning, but also encourage therapists to continue to use digital devices with their clients.

Recommendations

These findings have important implications for occupational therapy and use of application in a touch screen device. First, using a touch screen device promotes learning and motivates children with ASD in therapy and academy. Second, developing an

application with features that are suitable for children with ASD is essential as the lack of this has discouraged OTPs to use it in practice although it helps their clients. Third, using game-based application on a touch screen device encourages children with ASD in developing their fine motor skills which are essential for achieving independence and school-based skills. As a result, this will further benefit the educational access and quality of life of children with ASD.

Conclusion

Technology use has become more popular in therapeutic settings. Research studies found that technology has benefits towards children with disability in learning (Sung et al., 2016). However, children with ASD would not benefit from every individual application in the current market due to limitations and absence of features that meet critical needs. This innovative application created in this project provides a platform for children with ASD to learn and develop their fine motor skills through a touch screen device and reassures OTPs that they can effectively implement it in their practice with their clients.

APPENDIX G – Fact Sheet

BOSTON UNIVERSITY

Using applications on a digital device as intervention during therapy sessions to enhance the fine motor skills of children with autism spectrum disorder

Kelly Kan, OTR
OTD Candidate

Autism Spectrum Disorder (ASD) Facts

Children with ASD have a lower level of fine motor skills and this can lead to poor school performance, which then contribute to low self-esteem, decreased confidence and a poor quality of life. Children with a more severe level of ASD have greater impairment in motor skills.

The Problem

A touch screen device is increasingly used in occupational therapy intervention to help individuals with ASD to manage self-care, sensory issues, and social engagement. Children with ASD would benefit from using a touch screen device in improving their visual motor, cognition and social skills. However, there are limits to the efficacy of existing applications dedicated to the improvement of fine motor skills and no application targets children with ASD.

Result of the author's survey

Limitation of existing applications	Features supporting children with ASD
1) Lack of visual display for monitoring progress (n=14)	1) Simple to use (n=10)
2) Lack of visual rewards (n=10)	2) Simple layout (n=8)
3) Lack of sound reward (n=10)	3) A timer (n=7)
4) Lack of visual effect for wrong answers (n=8)	4) Sounding effects for wrong answers (n=7)
5) Lack of sound effect for wrong answers (n=4)	5) Visual reward (n=6)
6) Busy background and sensitivity settings (n=19)	6) Visual effect (n=5)
7) Not colorful (n=1)	7) With simple instruction (n=5)
	8) Setting a time limit for each game (n=4)

Photo By David Spero from Illumination

Photo By Laura Sanders from Insider

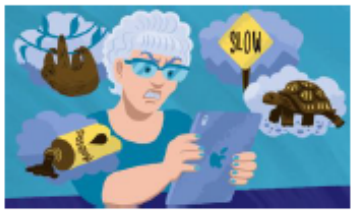


Photo By Daniel Nations from Lifewire

Theories

Technology Acceptance Model

- Key elements including perceived usefulness, perceived ease of use and behavioral intention inform that users will be more likely employing a specific application system when it is easy and enahnce an individual's work or life performance

Diffusion of Innovations

- DOI emphasizes the importance of conveying an innovation's perceived attributes of relative change, complexity, compatibility, observability and trialability features in persuading potential users to adopt it.

Proposed Solution

Finger Up is an application developed in this project that covers the limitation of the existing application and also includes all the features suggested from the survey.

Finger Up logo

Program

- Occupational therapy practitioners (OTPs) to receive three virutal training workshops prior to implementation
- OTPs to implement *Finger Up* with their clients in a 30-minute therapy session, five days a week for three months
- OTPs to receive a monthly virtual meeting for feedback and technical support throughout the three-month intervention

Program Outcomes

- Increased engagement in learning in children with ASD during therapy
- Increased knowledge of *Finger Up* and technology use in OTPs
- Increased fine motor skills in children with ASD
- Allowing children with ASD to transfer skills learnt in *Finger Up* to reality

Impact on Occupational Therapy Practice

- *Finger Up* is a theory-driven and evidence-based application that is easily accessible by OTPs when working with their clients in practice
- *Finger Up* with supportive and appropriate features exemplifies how children with ASD would benefit from using a touch screen device to develop their fine motor skills

References

Axford, C., Joosten, A. V., & Harris, C. (2018). iPad applications that required a range of motor skills promoted motor coordination in children commencing primary school. *Australian Occupational Therapy Journal, 65*, 146-155. https://doi:10.1111/1440-1630.12450

Chmiliar L. (2017). Improving learning outcomes: The iPad and preschool children with disabilities. *Frontiers in psychology, 8*, 660. https://doi:10.3389/fpsyg.2017.00660

Coutinho, F., Bosisio, M. E., Brown, E., Rishikof, S., Skaf, E., Zhang, X., …Dahan-Oliel, N. (2017). Effectiveness of iPad apps on visual-motor skills among children with special needs between 4y0m-7y11m. *Disability and Rehabilitation: Assistive Technology., 12*, 402-410. https://doi:10.1080/17483107.2016.1185648.

Dessoye, J., Converse-Korhonen, C., McLaughlin, L., McSweeney, S., & Steinhoff, C. (2017). The Effectiveness of iPad handwriting applications in improving visual–motor and handwriting skills in children with autism spectrum disorder. *The American Journal of Occupational Therapy, 71*, 7111520282. https://doi:10.5014/ajot.2017.71S1-PO2149

Jones, M., Morris, J., & Deruyter, F. (2018). Mobile healthcare and people with disabilities: Current state and future needs. *International Journal of Environmental Research and Public Health, 15*, 515. https://doi:10.3390/ijerph15030515

Kim, H., Duran, C., Cameron, C. E., & Grissmer, D. (2018). Developmental relations among motor and cognitive processes and mathematics skills. *Child development, 89*, 476–494. https://doi:org/10.1111/cdev.12752

Sung, Y., Chang, K., & Liu, T. (2016). The effects of integrating mobile devices with teaching and learning on students' learning performance: A meta-analysis and research synthesis. *Computers and Education, 94*, 252-275. https://doi: 10.1016/j.compedu.2015.11.008

REFERENCES

Akbulut, Y., & Cardak, C. S. (2012). Adaptive educational hypermedia accommodating learning styles: A content analysis of publications from 2000 to 2011. *Computers & Education, 58,* 835–842. https://doi:org/10.1016/j.compedu.2011.10.008

Akyurek, G., Kars, S., Celik, Z., Koc, C., & Cesim, O. (2017). Assistive Technology in Occupational Therapy. In M. Huri (Eds.), *Occupational Therapy - Occupation Focused Holistic Practice in Rehabilitation.* (pp. 92–115). IntechOpen. https://doi.org/10.5772/intechopen.68471

Ali, Z. & Bhaskar, S. B. (2016). Basic statistical tools in research and data analysis. *Indian Journal of Anaesthesia, 60*(9), 662–669. https://doi.org/10.4103/0019-5049.190623

Allen, M. L., Hartley, C., & Cain, K. (2016). iPads and the use of "apps" by children with autism spectrum disorder: Do they promote learning? *Frontiers in Psychology, 7*, 1305. https://doi: 10.3389/fpsyg.2016.01305

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). https://doi.org/10.1176/appi.books.9780890425596

Anzulewica, A., Sobota, K., & Delafield-Butt, J. T. (2016). Toward the autism motor signature: Gesture patterns during smart tablet gameplay identify children with autism. *Scientific Reports, 6*, 31107. https://doi:10.1038/srep31107

Axford, C., Joosten, A. V., & Harris, C. (2018). iPad applications that required a range of motor skills promoted motor coordination in children commencing primary school. *Australian Occupational Therapy Journal, 65*, 146–155. https://doi:10.1111/1440-

1630.12450

Brown, H. V., & Hollis, V. (2013). The meaning of occupation, occupational need, and occupational therapy in a military context. *Physical Therapy, 93*, 1244–1253. https://doi:10.2522/ptj.20120162

Bhat A. N. (2021). Motor impairment increases in children with autism spectrum disorder as a function of social communication, cognitive and functional impairment, repetitive Behavior severity, and comorbid diagnoses: A SPARK study report. *Autism Research, 14*(1), 202–219. https://doi.org/10.1002/aur.2453

Butler, C., Pimenta, R., Tommerdahl, J., Fuchs, C. T., & Caçola, P. (2019) Using a handwriting app leads to improvement in manual dexterity in kindergarten children. *Research in Learning Technology, 27*(2135), 1–10. http://doi: 10.25304/rlt.v27.2135

Cai, S., Zhu, G., & Wu, Y. (2018). A case study of gesture-based games in enhancing the fine motor skills and recognition of children with autism. *Journal Interactive Learning Environments, 26*(8), 1039–1052. http://doi:10.1080/10494820.2018.1437048

Ceccarelli, B. S., Ferrante, C., Gazzola, E., Marzocchi, G. M., Nobile, M., Molteni, M., & Crippa, A. (2020). Fundamental motor skills intervention for children with autism spectrum disorder: A 10-year narrative review. *Children (Basel, Switzerland), 7*, 250. https://doi.org/10.3390/children7110250

Chmiliar L. (2017). Improving learning outcomes: The iPad and preschool children with disabilities. *Frontiers in Psychology, 8*, 660. https://doi:10.3389/fpsyg.2017.00660

Coutinho, F., Bosisio, M. E., Brown, E., Rishikof, S., Skaf, E., Zhang, X., …Dahan-Oliel, N. (2017). Effectiveness of iPad apps on visual-motor skills among children with special needs between 4y0m–7y11m. *Disability and Rehabilitation: Assistive Technology, 12*, 402–410. https://doi:10.1080/17483107.2016.1185648.

Creek, J., & Bullock, A. (2008). Planning and implementation. In J. Creek & L. Lougher (Ed.), *Occupational therapy and mental health* (2nd ed., pp. 109–127). New York: Churchill Livingstone.

Criss, M. J. (2013). School-based telerehabilitation in occupational therapy: using telerehabilitation technologies to promote improvements in student performance. *International Journal of Telerehabilitation, 5*, 39–46. https://doi.org/10.5195/ijt.2013.6115

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13*, 319–340. https://doi.org/10.2307/249008

Dehghan, L., Mirzakhani, N., Rezaee, M, & Tabatabaee, M. (2017). The relationship between fine motor skills and social development and maturation. *Iranian Rehabilitation Journal, 15*, 407–414. doi: 10.29252/NRIP.IRJ.15.4.407

Dessoye, J., Converse-Korhonen, C., McLaughlin, L., McSweeney, S., & Steinhoff, C. (2017). The Effectiveness of iPad handwriting applications in improving visual–motor and handwriting skills in children with autism spectrum disorder. *The American Journal of Occupational Therapy, 71*, 7111520282. https://doi:10.5014/ajot.2017.71S1-PO2149

Dewey, D., Cantell, Marja, & Crawford, S. G. (2007). Motor and gestural performance in children with autism spectrum disorders, developmental coordination disorder, and/or attention deficit hyperactivity disorder. *Journal of the International Neuropsychological Society, 13*(2), 246–256. http://doi:10.10170S1355617707070270

Esposito, M., Sloan, J., Tancredi, A., Gerardi, G., Postiglione, P., Fotia, F., … Vicari, S. (2017). Using tablet applications for children with autism to increase their cognitive and social skills. *Journal of Special Education Technology, 32*(4), 199–209. https://doi.org/10.1177/0162643417719751

Green, D., Charman, T., Pickles, A., Chandler, S., Loucas, T., Frcpsych, E. S., & Baird, G. (2009). Impairment in movement skills of children with autistic spectrum disorders. *Developmental Medicine & Child Neurology, 51*(4), 311–316. https://doi:10.1111/j.1469-8749.2008.03242.x

Grob, G. F. (2015). Writing for impact. In H. P. Hatry, K. E. Newcomer, & J. S. Wholey (Ed.), *Handbook of Practical Program Evaluation* (3rd ed., pp. 739–764). Jossey-Bass.

Hamidi, F., Ghorbandordinejad, F., Rezaee, M., & Jafari, M. (2011). A comparison of the use of educational technology in the developed/developing countries. *Procedia Computer Science, 3*, 74–377. https://doi:10.1016/j.procs.2010.12.063

Hirata, S., Okuzumi, H., Kitajima, Y., Hosobuchi, T., Nakai, A., & Kokubun, M. (2014). Relationship between motor skill and social impairment in children with autism

spectrum disorders. *International Journal of Developmental Disabilities*, *60*, 251–256. doi:0.1179/2047387713Y.0000000033

Horn, M. B. (2019). Taking tablet learning global: Can learning technology eradicate illiteracy in less-developed countries? *Education Next, 19*, 86. https://doi:600918/j.593

Jones, M., Morris, J., & Deruyter, F. (2018). Mobile healthcare and people with disabilities: Current state and future needs. *International Journal of Environmental Research and Public Health, 15*, 515. https://doi:10.3390/ijerph15030515

Kamaruzaman, M. F., Noor, H. M., & Azahari, M. H. H. (2016). *Using touchscreen technology to support basic numeracy learning process for high functioning children with autism.* https://www.researchgate.net/publication/308117192_Using_touchscreen_technology_to_support_basic_numeracy_learning_process_for_high_functioning_children_with_autism

Kim, H., Duran, C., Cameron, C. E., & Grissmer, D. (2018). Developmental relations among motor and cognitive processes and mathematics skills. *Child Development, 89*, 476–494. https://doi:org/10.1111/cdev.12752

King, A. M., Brady, K. W., & Voreis, G. (2017). "It's a blessing and a curse'': Perspectives on tablet use in children with autism spectrum disorder. *Autism & Developmental Language Impairments, 2*, 1–12. https://doi:10.1177/2396941516683183

King, A. M., Thomeczek, M., Voreis, G., & Scott, V. (2013). iPad use in children and young adults with autism spectrum disorders: An observational study. *Child*

Language Teaching and Therapy, 30, 159–173. https://doi: 10.1177/0265659013510922

Kruger, G. R., Silveira, J. R., & Marques, A. C. (2019) Motor skills of children with autism spectrum disorder. *Revista Brasileira Cineantropometria Desempenho Humano, 21*, 1–8. http://dx.doi.org/10.1590/1980-0037.2019v21e60515

Kumaragama, K., & Dasanayake, P. (2015). iOS Applications (apps) for attention deficit hyperactivity disorder (ADHD/ADD): A preliminary investigation from Australia. *Journal of Mobile Technology in Medicine, 4*, 33–39. https://doi:10.7309/jmtm.4.2.5

Kushki, A., Chau, T., & Anagnostou, E. (2011). Handwriting difficulties in children with autism spectrum disorders: A scoping review. *Journal of Autism & Developmental Disorders, 41*, 1706–1716. https://doi:0.1007/s10803-011-1206-0

Lee, Y., Kozar, K. A., & Larsen, K. R. T. (2003). The technology acceptance model: Past, present, and future. *Communication of the Association for Information Systems, 12*. 752–780. http://doi:10.17705/1CAIS.01250

Lord, C., Elsabbagh, M., Baird, G., & Veenstra-Vanderweele, J. (2018). Autism spectrum disorder. *The Lancet, 392*, 508–520. http://doi:10.1016/S0140-6736(18)31129-2

MacDonald, M., Lord, C., & Ulrich, D.A. (2013). The relationship of motor skills and social communicative skills in school-aged children with autism spectrum disorder. *Adapted Physical Activity Quarterly: APAQ, 30*, 271–82. http://doi:10.1123/apaq.30.3.271

Memari, A. H., Panahi, N., Ranjbar, E., Moshayedi, P., Shafiei, M., Kordi, R., & Ziaee, V. (2015). Children with autism spectrum disorder and patterns of participation in daily

physical and play activity. *Neurology Research International, 7*, 531906. http://doi:10.1155/2015/531906

Mithyantha, R., Kneen, R., McCann, E., & Gladstone, M. (2017). Current evidence-based recommendations on investigating children with global developmental delay. *Archives of Disease in Childhood, 102*(11), 1071–1076. http://doi: 10.1136/archdischild-2016-311271

Newcomer, K. E. & Triplett, T. (2015). Using survey. In H. P. Hatry, K. E. Newcomer, & J. S. Wholey (Ed.), *Handbook of Practical Program Evaluation* (3rd ed., pp. 262–297). Jossey-Bass.

Paina, L., Namazzi, G., Tetui, M., Mayora, C., Kananura, R. M., Kiwanuka, S. N. . . . Elizabeth Ekirapa-Kiracho. (2019). Applying the model of diffusion of innovations to understand facilitators for the implementation of maternal and neonatal health programmes in rural Uganda. *Globalization and Health, 15*(1), 1–11. https://doaj.org/article/427ab274a34f4af2984f4702fc5c1c39

Ravenek, M., & Alvarez, L. (2016). Use of mobile 'apps' in occupational therapy: Therapist, client and app considerations to guide decision-making. *World Federation of Occupational Therapists Bulletin, 75*(1), 43–49. https://doi:10.1080/14473828.2016.1162430

Rodger, S., & Ziviani, J. (2006). Occupational therapy with children: Understanding children's occupations and enabling participation. *Occupational Therapy In Health Care, 22*(4), 87–89. https://doi:10.1080/07380570802244605

Schaaf, R. C., Benevides, T., Mailloux, Z., Faller, P., Hunt, J., Hooydonk, E., … Kelly, D. (2013). An intervention for sensory difficulties in children with autism: A randomized trial. *Journal of Autism and Developmental Disorders, 44*(10), 1493–1506. https://doi:10.1007/s10803-013-1983-8

Srinivasan, S. M., & Bhat, A. N. (2013). A review of "music and movement" therapies for children with autism: embodied interventions for multisystem development. *Frontiers in Integrative Neuroscience, 7*, 22. https://doi.org/10.3389/fnint.2013.00022

Sung, Y., Chang, K., & Liu, T. (2016). The effects of integrating mobile devices with teaching and learning on students' learning performance: A meta-analysis and research synthesis. *Computers and Education, 94*, 252–275. https://doi: 10.1016/j.compedu.2015.11.008

Surendran, P. (2012). Technology acceptance model: A survey of literature. *International Journal of Business and Social Research, 2*(4), 175–178. https://doi:10.18533/ijbsr.v2i4.161

The American Journal of Occupational Therapy. (2014). Occupational therapy practice framework: Domain and process (3rd Edition). *American Journal of Occupational Therapy, 68*(1), S1–S48. https://doi: 10.5014/ajot.2014.682006

Valencia, K., Rusu, C., Quiñones, D., & Jamet, E. (2019). The impact of technology on people with autism spectrum disorder: A systematic literature review. *Sensors (Basel, Switzerland), 19*(20), 4485. https://doi.org/10.3390/s19204485

Yamkovenko, S. (2018). *Apps for occupational therapy: Find apps for your practice area.* https://www.aota.org/Practitioners/Resources/Apps.aspx

Yavich, R., & Davidovich, N. (2019). Use of iPads in the education of children with autism-spectrum disorder. *Higher Education Studies, 9,* 214–225. https://doi.org/10.5539/hes.v9n4p214

Zhao, J., Fang, S., & Jin, P. (2018). Modeling and quantifying user acceptance of personalized business modes based on TAM, trust and attitude. *Sustainability, 10*, 356. https://doi:10.3390/su10020356

Zikl, P., Petru, D., Dankova, A., Dolezalova, H., & Safarikova, K. (2016). Motor skills of children with autistic spectrum disorder. *SHS Web of Conferences, 26*, 01076. https://doi.org/10.1051/shsconf/20162601076

CURRICULUM VITAE