Advisor: Dr. Laura Zieger

A CASE STUDY OF THE INTEGRATION OF ROBOTICS TO SUPPORT THE EDUCATIONAL AND THERAPEUTIC GOALS OF STUDENTS WITH LOW-INCIDENCE DISABILITIES

Stephanie Orosz Talalai

Educational Technology Leadership

Submitted in partial fulfillment of
the requirements for the degree of
Doctorate in Educational Technology Leadership
New Jersey City University
2018

Abstract

Teachers of students with severe multiple low-incidence disabilities have been tasked with the implementation of grade-level Common Core State Standards (CCSS) and content through all curriculum areas and academic skills. These school mandates often leave teachers searching for methods, best practices, accommodations, and tools to implement these new standards into their lessons and Individualized Education Programs. With the increasing use of STEM programs in schools, the use of technology, specifically robotics and coding, has become a key component in today's curriculum. The popularity of STEM education and the existence of robotics posed a unique opportunity for teachers, who work with students with disabilities, to differentiate instruction and provide multiple means of expression and engagement to their lessons. However, the specific problem is that the implementation and perceived impact of robotics for the education and therapeutic goals of students classified with low-incidence disabilities remain unknown. This exploratory case study offered the unique opportunity to explore how teachers, therapists, and administration of the A. Harry Moore School select, implement and instruct students with low-incidence disabilities with robotics and incorporate Universal Design for Learning principles. Through observations and interviews, this study examined teacher, therapeutic, and administrative knowledge, implementation and perceptions of the use of robotics and how they impact student educational and therapeutic goals. The study found that teachers and therapists of students with low-incidence disabilities use robotics to increase student motivation, engagement, performance, and enjoyment. Robotics can help students meet the federal mandates to perform at the level of their non-disabled peers.

Dedication

This dissertation is dedicated to my beautiful family for being a constant lifeline of love, support, and encouragement.

All our dreams can come true, if we have the courage to pursue them.

-Walt Disney

Acknowledgements

They say it takes a village to raise a child. It takes the guidance, support, and love from so many people to complete a dissertation. I would like to give a special thanks to Dr. Laura Zieger for accepting my "chair-posal" and guiding me on this journey with honest feedback and unwavering support. I would also like to thank Dr. Tracy Amerman and Dr. Christopher Shamburg for serving on my committee. I appreciate all of the time and effort you have put into this process. Thank you to my husband Anthony for not only your love and support but for all the dinners you cooked for me and for enduring so many lonely nights on the couch while I spent so many nights in the basement. To my children, Alyssa and Brandon, for constantly encouraging me to keep going. I Love you. To my Mom and Dad, my sister Denise and my Aunt Mary, thank you for your support and believing in me. To my bestie, Tracy Nimon, your daily words of encouragement and having you there to listen to me on a daily basis meant more to me than you will ever know (what happens in the car, stays in the car). To Trish Holzman and Wendy Thompson, what would I have done without my A. Harry Moore buddies? I am so glad that we were able to go on this journey together and have each other for support. To my Jersey Shore girls, Ruth-Anne Sokol, Jen Vanyi and Daun Ward, your friendship and moral support meant the world to me. Finally, I would like to thank all the members of Cohort 3. There isn't another group of people in the world I would have wanted to go on this journey with, "3 fingers in the air!"

TABLE OF CONTENTS

CHAPTER IV: FINDINGS OF THE STUDY

List of Tables

List of Figures

Chapter I: Overview of the Study

Introduction

In recent years, teachers of students with severe multiple low-incidence disabilities have been tasked with the implementation of grade-level Common Core State Standards (CCSS) and content through all curriculum areas and academic skills (Spooner, McKissick, & Knight, 2017). Furthermore, under the No Child Left Behind Act (NCLB, 2001) and Every Student Succeeds Act (ESSA, 2015), even students with the most significant disabilities are being assessed on alternate achievement standards, which are linked to matching grade-level standards (Kleinert et al., 2015). These school mandates often leave teachers searching for methods, best practices, accommodations, and tools to implement these new standards into their lessons and Individualized Education Programs (IEP), legal documents that outline the modifications and accommodations, the learning goals and objectives, the educational and therapeutic services, and the evaluation measures for every student with a documented disability who attends an educational program (Stanberry, n.d.).

In 1975, the United States enacted the Education for All Handicapped Children Act (PL 94-142), which guaranteed a "free and appropriate" education in the "least restrictive environment" for all students with disabilities. This pioneering legislation allowed for students with disabilities to be included in their regular public schools with access to the general curriculum (Browder et al., 2014). The Individuals with Disabilities Education Act (IDEA, 1997) and the Individuals with Disabilities Education

Improvement Act (IDEIA, 2004) set mandates in place so that assistive technology (AT) would be considered when planning the Individualized Education Program (IEP) of each disabled student. “This landmark policy sought to ensure that all students who could benefit would have access to assistive technology devices and services to maximize the benefit they receive from their educational programs” (Edyburn, 2003, p. 130). In relation to the need for AT, the Technology-Related Assistance for Individuals with Disabilities Act (PL 100-407) or Tech Act was enacted in 1988. The purpose of this regulation was to increase the availability, improve ease of access, and provision of funding for AT through state efforts and national initiatives (Perelmutter, McGregor, & Gordon, 2017). In 2004, the Assistive Technology Act was implemented to remove the sunset provision or the limited implementation period of the Tech Act (Leopold, Lourie, Petras, & Elias, 2015). Moreover, the Tech Act provided a precise definition of AT and stated explicitly that the focus would be on developing and supporting state efforts to improve AT provision to individuals with disabilities of all ages (Leopold et al., 2015). These mandates point to the inclusion of assistive technologies to aide students with disabilities in achieving their IEP goals and objectives and state standards.

IDEIA (2004) categorizes the full range of disabilities eligible for special education services into two distinct groups, Low-Incidence Disabilities and High-Incidence Disabilities. A disability is considered as low-incidence when its occurrence rate is less than 1% of the total enrollment from kindergarten through grade 12 of a given state (Ajuwon, Sarraj, Griffin-Shirley, Lechtenberger, & Zhou, 2015). Students with low-incidence disabilities are classified as having developmental disabilities, visual and hearing impairments, severe and multiple disabilities, or severe cognitive impairments including any that which make students eligible for early intervention services (IDEIA, 2004). On the other hand, high-incidence disabilities have an occurrence rate of 10% of school-aged children (Trainor, Morningstar, & Murray, 2016). Students with high-incidence disabilities are classified as having learning disabilities, speech and language impairments, mental retardation and emotional disturbances and are more common in the special education student population (IDEIA, 2004). In addition, schools are now held accountable for ensuring that students with disabilities not only participate fully in their education program but also make adequate yearly progress in the general education curriculum (No Child Left Behind, 2001).

With the increasing use of technology to aid learning in the 1990s, assistive technological tools for students with disabilities have been developed during the same decade (Fichten, Asuncion, & Scapin, 2014). Because of the accountability of schools in ensuring students perform successfully in their academics, assistive technologies have been developed to allow students with complex, low-incidence physical, sensory or cognitive disabilities to benefit from the technological intervention by speaking and participating academically (DeCoste, 2013). Over time, new technologies were designed to address the reading, writing, and organizational needs of students with learning disabilities, language disorders, high-functioning autism and attention deficit disorders (DeCoste, 2013).

Students with disabilities have benefitted from the technological advances in augmentative communication, wheelchair mobility, computer access, and prosthetics. These specialized devices often alleviate many of the problems faced by the disabled population. Students with disabilities can now control a computer or speech-generating device with just their eyes or voice, have a 3D printed prosthetic limb or even get to a standing position by pressing a button on their wheelchairs. These "assistive technology devices and services aid individuals with disabilities to actively engage in classroom and social activities, as well as functional living and work responsibilities, independently or with minimal assistance" (Poel, Wood, & Schmidt, 2013, p. 29). With these technological advancements, teachers of students with disabilities also have an essential role to play in ensuring that the students realize the intended advantages of the new technologies for their population.

Teachers of students with severe multiple low-incidence disabilities have sought to give these children, who were frequently excluded from the educational process, the same educational experiences as their typically developing peers (Downing & MacFarland, 2010). This initiative often requires educators to find the best piece of technology, assistive learning tool or mobile application (Hayes, 2013). These specialized tools and devices allow students with disabilities to have greater access to the curriculum, improved functional capabilities, and an increase in classroom participation (Alkahtani, 2013). For successful implementation, support from the government and the school administration, access to the appropriate equipment and technology supports and collaboration, and professional development are all essential elements of the program (Messinger-Willman & Marino, 2010).

In 2009, then President Obama launched the Educate to Innovate initiative in an effort to improve national achievement in science and math for America's youth. In 2010, the President's Council of Advisors on Science and Technology (PCAST) released a report outlining the ways to better prepare students for Science, Engineering, Technology, and Math (STEM) careers. Since then, STEM education has become more prevalent in the classroom. Makerspaces, coding, and robotics are frequently used to enhance the STEM curriculum. The introduction of robotics in STEM education has shown an increase in the creativity, collaborative skills, and critical thinking in primary and secondary students (Khanlari, 2013). Through robotics, teachers can provide captivating hands-on activities for integrating a variety of curricular areas (Bers, 2008). When robotics are used in education, students develop better collaborative, problem-solving, and communication skills (Benitti, 2012). Unfortunately, these STEM-related technologies often are not being utilized in classrooms for students with the most significant disabilities as many teachers are unable or ill-equipped to address the unique needs of these students or fail to develop lessons or class content according to universal design for learning principles (Moon et al., 2012). This researched based framework for curriculum design that gives all students, even those with disabilities, the same learning opportunities and curricular access (Basham et al., 2010; Rose & Meyer, 2002). Being denied access to these STEM-related technologies, students with disabilities cannot gain the skills needed to complete their degrees and access employment and a life of self-sufficiency (Isaacson, Schleppenbach, & Lloyd, 2014; Izzo & Bauer, 2015). Therefore, modifications to some STEM-related technologies must be provided to adjust to the limitations of students with disabilities (Isaacson et al., 2014). Similarly, teachers who will teach and use the said technological strategies or tools must be equipped with the necessary skills for proper implementation of the initiative (Heinrich, Knight, Collins, & Spriggs, 2016).

For the federal mandates to be effective and for the students to reap the benefits of the latest advances in assistive technology devices and STEM-related technologies, teachers need to receive the proper training on how to choose, implement, and support these technologies for their students. Although federal law requires that Assistive Technology be considered and utilized for all students with an IEP, research has indicated that teachers are not being adequately prepared for the consideration and effective utilization of AT (Naraian & Surabian, 2014).

According to the Individuals with Disabilities Act (IDEA, 1997), students with low-incidence disabilities need to be educated in the least restrictive environment, but for some students with the most severe health issues and impairments, the least restrictive environment is often a specialized school. New Jersey was one of the first states that had a policy catering to students with learning disabilities as early as 1911 (New Jersey Department of Education, 2005). In 1954, three bills on education were enacted. One of these bills categorized students who were then considered mentally retarded as one of the following: (a) educable mentally retarded; (b) trainable mentally retarded; (c) not educable or trainable. By having a category that pertained to not educable or trainable students, New Jersey excluded some children from the public education system at that time (New Jersey Department of Education, 2005). This has been amended wherein those who were considered as not educable or trainable were referred to as eligible for day training. Similarly, in 1977, the role of the state of New Jersey in providing financial support for the public education sector to cater to the needs of students with disabilities was extended to private educational institutions. Currently, the government of New

Jersey still provides support for catering to the needs of its disabled students, including the professionals who attend to their educational requirements (Troccoli, 2017).

The A. Harry Moore School in Jersey City, New Jersey was established in 1931 as one of the first public schools for students with physical disabilities in the United States. Funding for the school was obtained by then Governor A. Harry Moore for whom the school was named. A. Harry Moore was part of the Jersey City public school district until 1963 when Jersey City State College leased the school from the City of Jersey City to establish a laboratory school for their special education program (www.njcu.edu).

Today, A. Harry Moore educates approximately 120 students between the ages of three and 21 classified as preschool disabled, learning and language disabled or multiply disabled. Because of the school's unique history as a demonstration school, they have developed an expertise in educating students with severe multiple low-incidence disabilities. In recent years, A. Harry Moore students have been featured in several articles showcasing their unique use of 21^{st}-century skills such as wearable technology and robotics.

In a featured *New York Times* article, A. Harry Moore School was recognized for their technology integration practices for students with low-incidence disabilities. Each classroom at A. Harry Moore has technology that promotes the independence of students with disabilities while working on a task or activity. Teachers claimed that such situation would not have been possible for most of these students a few decades ago (Kanno-Youngs, 2016). Teachers at the A. Harry Moore School regularly supplement student instruction with the use of robotics. A recent *Daily Genius* article (Pepe, 2016) featured the use of robotics to enhance reading, math, social studies and digital storytelling at the

A. Harry Moore. Moreover, Pepe (2015) stated that A. Harry Moore promotes inclusive education through a digital collaboration program that features inclusion by pairing up with Toms River, which is the largest suburban district in New Jersey. Therefore, through the digital collaboration (e.g., through Google Hangout), students from A. Harry Moore were able to share their experiences to their non-disabled peers with the help of technology (Pepe, 2015). Similarly, students from each school shared robotics programs and development to each other; therefore, creating a digital inclusion classroom (Pepe, 2015).

Similarly, the use of robotics has enhanced the art curriculum giving students the ability to paint like Jackson Pollock or draw without the use of their hands. Researchers have used robotics as topics in classes as a form of AT (Barros et al., 2017; Conti, Commodari, & Buono, 2017; Lindsay & Hounsell, 2017). Lindsay and Hounsell (2017) claimed that robotics is an effective form of AT, especially for students with disabilities engaging in the science, technology, and mathematics (STEM) program. Conti et al. (2017) claimed that robotics could be an assistive tool for teaching students with disabilities; provided the teachers have the necessary training in the use of robotics in education. Robotics are also being utilized by physical, occupational and speech therapists to encourage walking, writing, and communication. The use of low-cost robots has successfully allowed teachers and therapists to differentiate instruction and present students with multiple means of engagement and expression.

Statement of the Problem

Based on No Child Left Behind, students with disabilities are required to have access to, and make yearly progress, in the same academic curriculum as their non-disabled peers (Hodge & Welch, 2016; Hourigan, 2014). Additionally, teachers of students with disabilities are required by the Every Student Succeeds Act to assess their students on the same standards as their typically developing peers (Hodge & Welch, 2016). The Individuals with Disabilities Education Improvement Act of 2004 also requires that assistive technology be considered for all students with an Individualized Education Program (IEP) (Jones, 2015). The general problem is that despite the different mandates involving educational rights of students with disabilities, teachers are not being trained on the implementation of technology, which can play a key role in curricular development for students with disabilities (Jones, 2015).

With the increasing use of STEM programs in schools, the use of technology, specifically robotics and coding, has become a key component in today's curriculum (Damiani & Ascione, 2017; Ko & Ladner, 2016; Lindsay & Hounsell, 2017). Robotics is one of the common technologies incorporated in classrooms to engage students with disabilities in learning and developmental activities (Damiani & Ascione, 2017; Lindsay & Hounsell, 2017). The popularity of STEM education and the existence of robotics posed a unique opportunity for teachers who work with students with disabilities to differentiate instruction and provide multiple means of expression and engagement to their lessons (Kaboski et al., 2015). Several studies have been conducted on the use of Humanoid Robots with children classified autistic (Grynszpan, Weiss, Perez-Diaz, & Gal, 2014; Kaboski et al., 2015; Yuen, Mason, & Gomez, 2014). Most robotics-based interventions have clearly defined activities and reduced distractions from unnecessary sensory stimuli, which make them effective for promoting learning and educational development for students with autism (Grynszpan et al., 2014). However, the specific problem is that the implementation and perceived impact of robotics for the education and therapeutic goals of students classified with low-incidence disabilities remain unknown. This study offered the unique opportunity to explore how teachers, therapists, and administration of the A. Harry Moore School select, implement and instruct students with disabilities with robotics.

Purpose of the Study

The purpose of this exploratory case study was to explore the perceptions of how the use of robotics can support the education and therapeutic goals of students with low-incidence disabilities. With the lack of teacher training on the use of robotics in special education classrooms and the absence of research on their use in low-incidence disabilities classrooms (Blackwell, Wartella, Lauicella, & Robb, 2015), its purpose was to evaluate teacher, therapeutic and administrative knowledge, implementation and perceptions of the use of robotics for students with low-incidence disabilities in a specialized school setting to gain an understanding of how they impact their educational and therapeutic goals. The A. Harry Moore School in Jersey City, New Jersey is a specialized school recognized for its use of robotics with students with disabilities. Through classroom observation and interviews, this study not only highlighted their successful implementation of robotics but also informed the reader of practices which should be avoided. The results of this study contributed to the understanding and best practices of how robotics may be incorporated into the educational programs of students with low-incidence disabilities.

Theoretical Framework

All students need assistance when learning, but it is vital that this assistance be diverse and meets the student's strengths, needs, and interests (Grasmick, 2011). Universal Design for Learning (UDL) is a teaching and learning framework that helps to ensure that every child has a learning experience that is multi-dimensional, multi-sensory, significant, and exciting (Brand & Dalton, 2012). UDL encourages the "design of instructional materials and activities that allows learning goals to be attainable by individuals with wide differences in their abilities to see, hear, speak, move, read, write, understand English, attend, organize, engage, and remember without having to adapt the curriculum repeatedly to meet special needs" (Orkwis & McLane, 1998, p. 9). UDL implementation incorporates effective instructional practices by thoughtfully including options for how material is presented, combined with multiple means of action, expression and engagement (DeCoste, 2011).

UDL guided this study as a researched-based framework for curriculum development that provides powerful supports for learning while reducing the barriers often encountered by students with disabilities (Center for Applied Special Technology [CAST], 2011). Universal Design for Learning (UDL) is based on three primary principles:

- "Multiple means of representation, to give diverse learners options for acquiring information and knowledge,
- Multiple means of action and expression, to provide learners options for demonstrating what they know,

- Multiple means of engagement, to tap into learners' interests, offer appropriate challenges, and increase motivation" (Center for Applied Special Technology [CAST], 2011).

As one of the principles of UDL, the use of multiple means of representation has long been recognized as one of the most effective methods for accommodating students with disabilities (Moon et al., 2012). Therefore, curriculum development should involve multiple or flexible modes of representation or teaching techniques that will cater to the different capabilities and needs of students. This study explored teacher use of classroom robotics as a tool to differentiate instruction and present students with an engaging and motivating means to access curricular material. The concept of multiple means of representation required the teachers to use classroom instruction methods presented in different or flexible modalities to align with the capabilities of their students within a classroom of students with a wide variety of disabilities.

The Technology Acceptance Model (TAM), developed by Davis in 1985, is a second theoretical framework relevant to the use of robotics in the education of students with disabilities (Davis, 1985). Davis (1985) developed TAM to predict the likelihood that individuals would adopt specific technologies. According to Davis (1985), individuals were more likely to adopt or "accept" a technology if they perceived the technology to be both useful and easy to use. The theory of TAM holds that individuals are less likely to use a technology if they lack the skills or technological confidence to engage with the interface or operate it. Furthermore, an individual's perceived usefulness is highly relevant to their likelihood of adopting a specific technology, meaning ease of operation is generally not a sufficient motivator (Davis, 1985). Applied to the use of robotics in the education of students with disabilities, TAM suggested that teachers are more likely to use robotics in their classrooms if they understand how robotics would benefit themselves and their students and feel confident in the operation of robotics (Davis, 1985).

Research Questions

The research questions that guided this study are:

1. What role does administration play in successful school-wide robotics implementation?
2. How do teacher's and therapist's knowledge and implementation of robotics influence the attainment of educational and therapeutic IEP goals for students with low-incidence disabilities?
3. What patterns emerge in the experiences and perceptions of teachers, therapists, and administrators during the implementation of robotics as an educational and therapeutic tool for students with low-incidence disabilities?
4. What principles of UDL are represented by the implementation of robotics into curricular activities for students with low-incidence disabilities in their classrooms?

Significance of the Study

This study explored how teachers and therapists from the A. Harry Moore School educate students with low-incidence disabilities by implementing robotics into their lessons. The study identified practices for implementation and highlighted the educational and therapeutic benefits of using robotics with students who have severe multiple physical and cognitive disabilities. With the focus on both robotic technology and multiply disabled learners, this study explored the practices and implementations of robotics to assist teachers and therapists of students with low-incidence disabilities develop activities and learning opportunities that will enhance their educational and therapeutic goals. This study is significant in that it will impact how teachers and therapists use robotics to attain educational and therapeutic goals for students with low-incidence disabilities. It also explained the relationship between robotics use and teacher's perception of robotics within the low-incidence disabled classroom.

Methodology

This exploratory study employed a descriptive qualitative single case study design to learn more about the perceptions, experiences, and common practices that teachers and therapists of students with low-incidence disabilities use to implement robotics within their classrooms. The researcher explored how teachers and therapists utilized the principles of UDL to implement robotics into the learning environment and consequently recorded their perceptions on student level of engagement. This study also attempted to ascertain the administrative steps needed for successful implementation. Yin (2013) stated that case studies are used when the researcher is exploring the "how" and "why" of a question, is studying a present-day issue, and when the researcher does not have control over the results. Merriam (1998) claimed that descriptive case studies are useful in "presenting basic information about areas of education where little research has been conducted" (p. 38). Descriptive case studies are used when innovative programs and practices are being studied (Merriam, 1998). Collecting data in multiple forms and spending a significant length of time gathering data in the "natural setting" are characteristics of a qualitative study (Creswell, 2014).

After receiving IRB approval, the researcher sought permission from the administration of the A. Harry Moore School to conduct observations and one-on-one interviews with teachers and therapists who frequently use robotics during regular classroom instruction and therapeutic interventions. Administrators were also asked to provide insight into their role in successful implementation. All classroom teachers and therapists were invited to participate. Through these observations and interviews, the researcher provided a glimpse into the school's best practices for robotics implementation. The researcher collected qualitative data using semi-structured interviews with the school administrators, teachers, and therapists. Additionally, the researcher observed lessons and therapeutic sessions where robotics was being used to enhance instruction and document activities that provide students with multiple means of representation, expression, and engagement. Through these observations and interviews, the researcher provided examples of robotics implementation and administrative perspectives that can be used to inform and inspire teachers of students with low-incidence disabilities on how to integrate robotics into their curricular activities. By observing and interviewing teachers, therapists, and administrators, multiple data sources were used to obtain rich descriptions and increase the reliability through triangulation (Yin, 2013). A more detailed description of the methodology will be presented in chapter 3.

Definition of Terms

Assistive Technology: is defined by the US 'Technology-Related Assistance of Individuals with Disabilities Act of 1988' (PL 100-407) as 'any item, piece of equipment, or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve functional capabilities of individuals with disabilities' (Scherer, 2002).

Individualized Education Program (IEP): a written plan defining the program that is designed to meet the unique needs of one child. The Individuals with Disabilities Education Act (IDEA) requires public school districts to develop an individualized plan for every child who qualifies as having one of the identified thirteen disabilities identified by IDEA as a qualifying condition for special education (UnderstandingSpecialEducation.com, 2016).

Low-incidence Disabilities: those disabilities involving visual and hearing impairments, developmental disabilities, severe and multiple disabilities, or severe cognitive impairments including any which make students eligible for early intervention services (IDEIA, 2004).

Occupational Therapy (OT): is a client-centered health profession concerned with promoting health and wellbeing through occupation. The primary goal of occupational therapy is to enable people to participate in the activities of everyday life (WFOT, 2012).

Physical Therapy (PT): Physical therapists provide services that develop, maintain and restore people's maximum movement and functional ability. They can help people at any stage of life when movement and function are threatened by aging, injury, diseases, disorders, conditions or environmental factors (WCPT, 2016).

Speech Therapy (ST): Speech-language pathologists (SLPs) work to prevent, assess, diagnose, and treat speech, language, social communication, cognitive-communication, and swallowing disorders in children and adults (ASHA.org).

Universal Design for Learning (UDL): UDL is composed of a set of principles for curriculum development with a proposition that (a) higher levels of student achievement are realized when teachers use a variety of teaching methods and materials (Hayden, 2011), (b) students should have an opportunity to express their skills and knowledge through multiple means in order to cater to the different strengths of learners (Edyburn, 2005), and (c) students are most successful when teachers use multiple means of engagement to increase student interest, motivation, and challenge (Edyburn, 2005).

Limitations

While there is a growing number of studies on the use of humanoid robots to increase socially acceptable behavior and eye contact in students classified as Autistic (Aresti-Bartolome & Garcia-Zapirain, 2014; Hedgecock, Standen, Beer, Brown, & Stewart, 2014), the researcher found few studies which focus on the use of robotics with students with other cognitive disabilities, especially in students with low-incidence disabilities. Data triangulation was achieved through observing and interviewing teachers, therapists and administrators; yet, the differing opinions and perspectives added challenge to the interpretation of the results (Hodkinson & Hodkinson, 2001). Additionally, the researcher’s personal biases and the time constraints imposed by the doctoral program could have affected the outcome of the study. These potential effects were minimized through the acknowledgment of personal expectations, experiences, and beliefs related to the topic of the study. The sample for this study was drawn from one school and from teachers and therapists who educate students with low-incidence disabilities. This sample was not representative of all special education teachers and therapists or regular public schools with self-contained classrooms.

Delimitations

A small sample size was selected to complete the study in a timely manner. However, the size was not representative of the general population of teachers who educate students with low-incidence disabilities. Even though the A. Harry Moore School educates students who have a wide variety of disabilities, this study did not categorize robotics use by specific disability as to protect the identity of the students. This study focused on the use of small, low-cost robotics for curricular implementation. Research has shown the use of humanoid robots to be effective when treating students with Autism (Aresti-Bartolome & Garcia-Zapirain, 2014). Yet, this study did not include the use of humanoid robotics nor did it concentrate on robotics use for students with Autism Spectrum Disorder.

Assumptions

Administrators, teachers, and therapists were willing to participate and answer interview questions honestly. Teachers and therapists were willing to be observed during the school day and that they would use robotics during their observations. It was assumed that the robotics would be in good working order, that they were charged, and that the teachers and therapists knew how to operate them and troubleshoot when a complication arises. It was also assumed that the STEM-related technologies in the classroom of the teachers involve robotics. It was also assumed that teachers and therapists have the ability to use technological tools for STEM and the skills to teach students with disabilities appropriately. Finally, it was also assumed that through interviews and observations, the researcher would collect enough data to adequately answer the research questions.

Chapter Summary

The topic of this chapter was the background of the issue related to the use of robotics as AT for students with low-incidence disabilities. The general problem was that despite the different mandates involving educational rights of students with disabilities, teachers are not being trained on the implementation of technology, which can play a key role in curricular development for students with disabilities (Jones, 2015). The specific problem was that the implementation and perceived impact of robotics for the education and therapeutic goals of students classified with low-incidence disabilities remain unknown. To address the specific problem, the purpose of this exploratory case study was to explore the perceptions of how the use of robotics can support the education and therapeutic goals of students with low-incidence disabilities. This problem and purpose was the focus of the discussion in chapter 1. In chapter 2, the discussion will be about the details of related literature within the context of robotics, AT, and students with low-incidence disabilities.

Chapter II: Review of the Literature

Introduction

Federal law mandates that all children, even those with severe low-incidence disabilities, be educated and assessed on the same standards as their non-disabled peers. These mandates often leave teachers of students with the most severe disabilities struggling for new, innovative and engaging ways to present curricular material. While the consideration of assistive technology has been required by law, newer technologies, such as robotics, have found their way into special education classrooms. Although some recent research studied the impact on robotics on the education of students with Autism, little current research focuses on implementation and impact of robotics when used with students classified with low-incidence disabilities. The purpose of the present study is to highlight examples and best practices of successful robotics implementation in the education of students with low-incidence disabilities. This literature review will focus on some of the events that have led to the use of robotics with students with low-incidence disabilities and how the principles of UDL contribute to their successful implementation.

The research analyzed in this literature review was gathered using Ebsco, JSTOR, ProQuest, and Google Scholar. The following search terms were used individually and collectively: robotics, education, disabilities, students, STEM, engineering, programming, and assistive technology. All of the search terms yielded information relevant to the present study.

This chapter will cover further background information relevant to the study and the theoretical framework. The literature review will cover a number of topics related to how robots and technology can be used in the education of individuals with disabilities. It includes sections on assistive technology, robotics in the education of students with Autism, robotics and the education of students with disabilities in general, and a case study on an early school designed to educate students with disabilities. Additionally, the literature review will analyze literature on smart schools, and lessons learned from people with disabilities and smart cities.

Theoretical Framework

Universal Design for Learning (UDL) is a researched based framework for curriculum design that gives all students, even those with disabilities, the same learning opportunities and curricular access (Basham et al., 2010; Rose & Meyer, 2002). The UDL framework was developed by David Rose and Anne Meyer at the Center for Applied Special Technology in 1997 (Edyburn, 2005). UDL was heavily influenced by the Individuals with Disabilities Act (IDEA), which brought national attention to how students with disabilities were educated in the United States and how to increase inclusion in public school classrooms (Edyburn, 2005). At the time, policymakers, lawmakers, educators, students, and parents feared that, though students with disabilities were permitted to attend public schools, they were not taught a curriculum which was comparable to their non-disabled peers (Edyburn, 2005).

The UDL principles are used to support learning for students with diverse needs. The goal of UDL is to “provide educators with a framework for understanding how to create curricula that meets the needs of all learners from the start” (CAST, 2011, p. 4).

Rose and Myer (2002) argue that the increasingly diverse student population were not being well served by education policies designed to take a uniform approach to all student education. According to Rose and Myer (2002), three key principles were crucial to the education of a diverse student body.

Firstly, UDL holds that higher levels of student achievement are realized when teachers use a variety of teaching methods and materials (Hayden, 2011). Secondly, students should have an opportunity to express their skills and knowledge through multiple means in order to cater to the different strengths of learners (Edyburn, 2005). Thirdly, students are most successful when teachers use multiple means of engagement to increase student interest, motivation, and challenge (Edyburn, 2005).

The Technology Acceptance Model (TAM), developed by Davis in 1985, is a second theoretical framework relevant to the use of robotics in the education of students with disabilities (Davis, 1985). TAM is less specific to the present study in that it was not developed specifically for education or students with disabilities. Davis (1985) developed TAM to predict the likelihood that individuals would adopt specific technologies. According to Davis (1985), individuals were more likely to adopt or "accept" a technology if they perceived the technology to be both useful and easy to use. The theory of TAM holds that individuals are less likely to use a technology if they lack the skills or technological confidence to engage with the interface or operate it. Furthermore, an individual's perceived usefulness is highly relevant to their likelihood of adopting a specific technology, meaning ease of operation is generally not a sufficient motivator (Davis, 1985). Applied to the use of robotics in the education of students with disabilities, TAM suggests that teachers are more likely to use robotics in their classrooms if they understand how robotics would benefit themselves and their students and feel confident in the operation of robotics.

Assistive Technology

Assistive technology is defined by the US 'Technology-Related Assistance of Individuals with Disabilities Act of 1988' (PL 100-407) as 'any item, piece of equipment, or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve functional capabilities of individuals with disabilities'. Internationally, this definition is generally accepted (Scherer, 2002). These technological advances in aids to communication, mobility, computer access and prosthetics often alleviate many of the problems faced by the disabled population today. In the United States, most assistive technology leaders start with a focus on students with complex, low-incidence physical, sensory or cognitive disabilities who can benefit from technology to speak and participate academically. Over time, new software tools were designed to address the reading, writing, and organizational needs of students with learning disabilities, language disorders, high-functioning autism and attention deficit disorders (DeCoste, 2013).

In 1997 the Individuals with Disabilities Education Act (IDEA, 1997) was reauthorized, and mandates were set in place so that assistive technology would be considered when planning the Individualized Education Program (IEP) of each disabled student. "This landmark policy sought to ensure that all students who could benefit would have access to assistive technology devices and services to maximize the benefit they receive from their educational programs" (Edyburn, 2003, p. 130). For these mandates to be effective, teachers need to receive the proper training on how to make appropriate AT choices for their students. Support of the administration and community, access to the appropriate equipment and technology supports and time for collaboration and professional development are essential for successful implementation (Messinger-Willman & Marino, 2010).

In 2014, Soorenian studied the implications of assistive technology in equalizing education between disabled and non-students with disabilities. Soorenian (2014) used a qualitative approach which included interviews and focus groups to discuss the benefits and challenges of using a variety of assistive technologies. According to Soorenian, a major benefit of using assistive technology in the classroom is that it can reduce student dependency on others for support, and allow students to learn independently (Soorenian, 2014). Furthermore, Soorenian argued that student needs are often unique, and educators should evaluate student needs before offering technological solutions which may be inefficient. For example, a screen-reader may be effective for one student with disabilities, but the same screen reader could be challenging for a student with similar disabilities, but who also is an international student and cannot follow speech as quickly (Soorenian, 2014).

As described by Sooreain, the purpose of many assistive technology studies is to close the “disability divide” in education (Sooreain, 2014). Sachdeva, Tuikka, Kimppa, Kai, and Suomi (2015) echoed the importance of equal education for all students while creating a conceptual framework for analyzing challenges in the education of students with disabilities and finding appropriate solutions. Using 4,778 conference and journal publications, the researcher performed an extensive literature review to draw conclusions about the most effective framework for educating students with disabilities. The researcher notes that, while studies were highly focused on the social and technological implications of assistive technology, there was little discussion on the cost of assistive technologies to either students or school institutions. The review of the literature revealed the importance of assistive technology in allowing students with disabilities to fully participate in classrooms including students with disabilities and students without disabilities (Sachdeva, Tuikka, Kimppa, Kai & Suomi, 2015).

Research on assistive technology supports its usefulness in reducing the education divide for students with disabilities, but Vidacek-Hains, Kozina, and Kirinic (2016) stress that the type of disability can significantly impact the needs of students in classrooms. In the study, the researchers sought to create a model for assessing the needs of students and implementing solutions in classrooms. The two-pronged research approach included soliciting feedback from educators and students on educating students with disabilities in a mixed classroom setting and trials involving peer assistants for students with disabilities. Over the course of study, the researchers determined that successful education of students with disabilities included a commitment from a variety of stakeholders including educators, parents, students, and local policymakers. Furthermore, the researchers determined that the sharing of resources between academic institutions lessened the overall financial burden and provided additional flexibility for meeting the needs of individual students. Finally, researchers determined that the successful implementation of assistive technology in classrooms included a significant commitment from teachers and teachers trained in such technologies. The researchers stressed that such skills were not inherent to all educators and that schools should have a high-quality human resources department with the ability to recruit and train appropriate teachers (Vidacek-Hains, Kozina & Kirinic, 2016).

Basak and Govender (2015) stress that implementing information communication technology (ICT) and assistive technology in classrooms can be challenging for teachers who are not familiar with the specific technology or competent with technology in general. A common problem uncovered in the use of ICT in classrooms is that teachers reported limited time to familiarize themselves with new technologies, as their typical work schedules are consumed with the education of students and the completion of tasks related to day to day student education (Basak & Govender, 2015). Other factors which limited teachers' ability to implement new technology in classrooms included a lack of sufficient access to technologies, a lack of technical support, inefficient training, resistance to change, and a lack of teacher confidence. Teachers play a crucial role in the education of students with disabilities and students without disabilities, so the effectiveness of assistive technology is partially dependent on a teacher's ability to support students with the use of recent technologies. In addition to developing and implementing assistive technologies in classrooms, teachers will need to receive high-quality training and education on the use of such technology (Basak & Govender, 2015).

Similarly, Smith, Ayres, Alexander, Ledford, Shepley, and Shepley (2016) found that self-instruction using videos or other ICT devices promoted educational achievement in students with ASD or intellectual disabilities. To evaluate the effectiveness of instructional videos and progressive time delay in education, the researchers taught the students to operate instructional devices, then studied their ability to learn a new task using the instructional videos. According to the researchers, learning through videos at a self-guided pace provided students with an opportunity to be independent, let them learn in a way which felt natural to them, and could potentially decrease the administrative challenge presented to educational institutions when many students need direct teacher assistance (Smith, Ayers, Alexander, Ledford, Shelpley & Shepley, 2016). The results of the study indicate that all students were able to self-instruct and that they maintained the skills they learned initially in subsequent settings. The study results suggest that students with disabilities are capable learning independently and that ICT and robotics can increase student engagement.

Creating and implementing effective assistive technology is complicated by the wide range of student needs and abilities. Assistive technology can benefit students with a wide range of physical and mental disabilities, but the technology employed must be appropriate to the individual student's needs (Yook & Kim, 2015). In 2015, Yook and Kim sought to improve the Korea-Computer Access Assessment, a test which objectively evaluated the ability of individual students and workers to utilize specific computer function to improve their access and to provide appropriate assistive technology. In conclusion, the researchers argued that educating students with disabilities required an understanding of their abilities and limitations to create the most productive and inclusive learning environment (Yook & Kim, 2015).

Seale, Georgeson, Mamas, and Swain (2015), asserted that "digital capital" needs to be carefully considered for each student, for technology in itself does not necessarily improve the educational outcomes of students with disabilities. Rather, finding the right mix of resources and technology is important for student educational and social development. In the 2015 study, Seale, Georgeson, Mamas, and Swain collected data from students with disabilities at a university in the United Kingdom using a closed-question questionnaire and numerous in-person interviews. The study results indicate that the vast majority of students with disabilities used some kind of assistive technology, but the type of technology used was greatly dependent on their personal preferences and disability type. According to the researchers, the university policy of providing students with disabilities with a "technology provision," rather than fixed technological tools, allowed students to successfully determine their own technological needs and avoid unnecessary or inappropriate purchases (Seale, Georgeson, Mamas & Swain, 2015).

Though initial costs of assistive technology may be high for individuals and schools, Alterovitz, Koenig, and Likhachev (2016) assert that such technology may result in costs savings when considered in the long run. According to the researchers, assisting people with disabilities to perform daily tasks such as eating and cleaning costs the US economy 350 billion dollars. Robots designed to perform such tasks could substantially reduce those costs if the technology progressed to a point where it was readily available, technologically sound, and capable (Alterobvitz, Koenig, & Likhachev, 2016). While the study primarily focused on assistive technology outside of the classroom, similar assistance is often required for students with disabilities. Similar to the benefits provided to people with disabilities regarding personal care and household help, applying assistive technology to educational institutions could increase the capacity of people with disabilities to participate in lessons and increase their self-sufficiency and independence (Alterobvitz, Koenig, & Likhachev, 2016).

Robotics and Autism

Technologies dedicated to the education and treatment of children with Autism Spectrum Disorder (ASD) have existed in therapeutic practices and educational institutions for years. The study of the use of robots with persons with ASD dates from 1999 and has gradually increased to date (Aresti-Bartolome & Gracia-Zapirain, 2014). Children with ASD are characterized by having difficulty interacting socially, exhibiting repetitive behaviors and communicating both verbally and non-verbally (www.autismspeaks.org). The predictable behavior, controlled social situations, and simple interactions of robots make them a useful treatment option for children with ASD (Aresti-Bartolome & Garcia-Zapirain, 2014).

In 2016, Huijen, Lexis, Jansens and De Witte studied how robots can be implemented to improve the education of students with ASD. Using a qualitative research format, Huijen, Lexis, Jansens and De Witte conducted 13 focus groups using 73 participants. The participants in the focus group were professionals working with individuals with ASD, and adults who identified as having ASD. An additional 22 participants included professionals, adults with ASD, and parents of children with ASD discussed the KASPAR robot and its implications for the education of children with ASD. The results of the study indicate that robots designed for use by children with ASD should have human characteristics, which are relatable and thoroughly considered. The robot should wear clothing similar to what children are used to seeing on themselves and their classmates, in patterns, which are not too vibrant or distracting. Furthermore, the voice of the robot should be soft, and tones should not convey loud or negative emotions. Additionally, the robot’s speech should be slow, but not jerky, and any additional sounds or noises should be announced before initiation (Huijen, Lexis, Jansens & De Witte, 2016).

According to Alley-Young (2016), robotics has many implications for assisting and helping to educate children with ASD. Many children with ASD have trouble identifying and learning to identify the emotional responses of their guardians, peers, and teachers, which can result in stress and confusion for students with ASD. Practicing identifying emotional responses can improve the ability of people with ASD, but such practice can be stressful for students. Robots designed to identify and teach emotional responses can provide stress-free practice for students (Alley-young, 2016). Such robotics have implications both in and out of the classroom and can provide long-lasting benefits for child and adult users. For widespread usage to be achieved, the Alley-Young (2016) asserts that parents and educators need to accept and utilize the technology, which requires both education, understanding, and technical support.

In 2012, Shamsuddin claimed that children with Autism responded well in both an educational and play-like setting to machines, sometimes interacting more confidently with robots than they did with people (Shamsuddin et al., 2012). Researchers believe that a robot with human characteristics including the ability to verbalize, blink its eyes and exhibit human-like movements would be more likely to elicit communication and reduce autistic-like behaviors. Human-Robot Interactions have the possibility of increasing the bonds between the child and the robot potentially enhancing their social skills (Yussof et al., 2012). A study conducted by Tapus et al. (2012), investigated whether autistic children exhibited increased initiation and social engagement behaviors when their actions were being mirrored by a NAO robot compared to a human partner. Of the four children participating in this study, all showed an increase in eye contact and social behaviors in the initial interaction with the Nao robot, but only two of them sustained those behaviors throughout the session. The small size of this study provides questions about its validity but suggests that the potential is there for its applications. These findings are consistent with the longitudinal study conducted by Robins, Dautenhahn, Koekhorst and Billard in 2005 who concluded that robots allowed children with ASD or mental disabilities to engage in unconstrained interactions which resulted in spontaneous, proactive, and playful social experiences.

The social deficits inherent in children with ASD and the various technological interventions developed to treat these deficits contributed to the introduction of socially assistive robots in treatment sessions. A study conducted by Kim et al. (2013), examined the social behaviors of 24 children with ASD who were asked to interact with an adult human, a touchscreen computer, and a robot. It was concluded that there was an increase in the general utterances of the children and that direct interactions with adults also increased after interaction with Pleo, a socially expressive robot dinosaur. Further studies into the long-term effects of continued interactions between social robots and children with ASD needs to be addressed. An analysis of student interactions, when presented with a choice between the Pleo and the Nao robots, would add to the discussion.

A similar study conducted by Lee, Takehashi, Nagai, Obinata & Stefanov (2012) explored the responses of 6 children diagnosed with autism to the facial expressions and verbal commands of both a human subject and an ifbot robot. Their study found an increase in eye contact, response to verbal cues and facial expressions after interactions with a robot that had distinct facial features and verbal capabilities. Further investigation with a larger number of participants was suggested at the conclusion of this study.

Similarly, Smitha and Vinod (2015) stressed the importance of helping children with ASD to identify the meaning and purpose of facial expressions in a stress-free, non-judgmental environment. Smitha and Vinod (2015) assert that interpersonal communication is mostly non-verbal and being able to recognize and connect with non-verbal communication can be challenging for children with ASD, which can have long-term impacts on their interpersonal relationships both in school and in the world. Smitha and Vinod (2015) claimed that assistive technology could be useful for students with ASD both in terms of helping them practically identify the emotions of their caretakers, in addition to helping them learn to recognize emotion independently. The proposed technology would include significant hardware, and the researchers stress that the portability and detection speed of such devices is currently a roadblock to widespread implementation. However, the avenue of research demonstrates the widespread application of assistive technology and robotics in improving the experience and education of students with ASD (Smitha & Vinod, 2015).

Though research on the impact of robotics on the education of students with disabilities is limited, studies which focus on robotics in general education suggest promising applications. According to Park and Kwon (2016), robotics are considered to have tremendous potential to alter the human experience, including changing the way students are taught. Even with the rapid improvement of information technology, teachers are sometimes slow to adopt robotics technology in everyday practice (Park & Kwon, 2016). Park and Kwon (2016) studied robotics adoption in classrooms using the

Technology Acceptance Model. Generally, the Technology Acceptance Model holds that individuals are more likely to adopt a technology if they perceive the technology to be both useful and easy to use (Davis, 1985). The researcher confirmed the principles of the Technology Acceptance Model in relation to the adoption of robotics in education, suggesting that teachers will need to fully understand the usefulness of robotics and be confident in their ability to use the technology before widespread adoption of robotics in classrooms is achieved (Davis, 1985).

A challenge of utilizing robotics for the assistance of students with ASD is the significant technological barrier to identifying and understanding human emotion (Cominelli, Carbonaro, Mazzei, Garofalo, & Tognetti, 2017). According to robotics researchers, assessing emotional states of humans is an incredibly complicated process for robotics frameworks, especially when it is expected to do so in real time. As previously mentioned, robotics designed to assist students with ASD to identify emotions in other individuals would need to be able to process, identify, and communicate human emotions almost instantly. Despite the challenge, the researchers assert that science is merely years, not decades, from developing reliable, portable technology (Cominelli, Carbonaro, Mazzei, Garofalo, & Tognetti, 2017).

Though emotion can be determined through a number of biological assessments, robots designed for use by students with ASD primary focus on face detection, facial recognition, expression analysis, vocal patterns, gesture analysis, and speech recognition. These verbal and visual cues can be used to predict human emotion, and do not require invasive or impractical techniques such as hormonal analysis or blood chemistry (Cominelli, Carbonaro, Mazzei, Garofalo, & Tognetti, 2017). According to the researchers, all works relating to facial and vocal analysis cite the portability of devices as a major roadblock, stating that devices are always visible and usually intrusive to students. Cominelli et al. stated that some challenges of such technology could be managed and reduced when robots are designed to identify emotion in a number of specified subjects, rather than in an unspecified human population. According to the researchers, robots are better able to identify emotions accurately if they have significant data on the emotional responses and expressions of individuals, which can vary from person to person (Cominelli, Carbonaro, Mazzei, Garofalo, & Tognetti, 2017).

Robots designed to serve an educational function for autistic students can take multiple forms, but potentially the least stressful educational tool would be robots which are designed to appear human and mimic human facial expressions (Tadesse, Wu & Saharan, 2016). The benefit of such a device is that students would not need to bring the technology with them when interacting with individuals in order to gain educational benefits. Using a device purely in a controlled academic setting would reduce the need for technology to be portable and reduces the technological challenge of identifying emotions in human subjects, who often limit their obvious emotional responses and express emotions in multiple ways. The technological development of facially expressive robots in different from robots designed to identify human emotion, but still challenging. Tadesse, Wu, and Saharan (2016) discuss the complexity required to mimic human musculature and suggest that 3-D printing devices could be useful in developing artificial joints and muscles.

In addition to providing educational support for students with autism, specialized robots can be useful in identifying children who may have ASD. As explained by Rihar, Mihelj, Matjaz, Janko and Munih (2015), early identification of autism in children can assist with optimizing the medical response and provide children with the most expedient educational interventions which can lead to improved social and educational outcomes. An example of robotics assisting with the diagnosis of autism is a recently developed mattress pad which measures head and limb movements in infants and children. According to the researchers, ASD and developmental delays often impact motor patterns which can be detected by sensory mattresses. The researchers assert that the technology is non-invasive and accurate, which can increase the rate of early identification and improve educational outcomes for children.

Robotics and other technological tools are useful for teaching students about STEM disciplines and getting kids interested in math and science (Adams & Cook, 2014). Studies suggest that the general population of students benefit from educational programs which utilize robotics, and students with ASD can receive similar benefits (Adams & Cook, 2014). Some researchers assert that engaging students with ASD using robotics could be particularly beneficial, as students with ASD may disproportionately show an interest in STEM disciplines in a college or university setting (Wei, Yu, Shattuck, McCracken, & Blackorby, 2013). According to Wei, Yu, Shattuck, McCraken, and Blackorby (2013), students with ASD are more likely to choose mathematics as a university major than medicine, law, or social sciences. Wei, Yu, Shattuck, McCraken, and Blackorby (2013) found that 34 percent of young adults with ASD choose to major in a STEM discipline, which represented a higher proportion than any other disability group. Though the research team asserts that many studies asserting the aptitude of ASD students in math and science disciplines are not generalizable, presenting students with an opportunity to learn about the subjects that interest them in primary and secondary schools set students up for greater success in universities and the workforce. In that manner, robotics present an opportunity not only to facilitate the education of students with ASD, but also to support their academic inclinations (Wei, Yu, Shattuck, McCracken, & Blackorby, 2013).

According to Mechling, Ayers, Foster & Bryant (2015), the educational benefits of technological or robotic learning platforms is partially dependent on the training students with autism receive prior to undertaking educational lessons with the devices. In order to study the importance of customized training before device usage, the researchers evaluated student educational achievement when the students were provided with instructions customized to the specific device versus generalized instructions. Though some students were able to reach educational objectives with both generalized and customized instructions at equal rates, most students committed more errors and took longer to complete lessons when provided with generalized instructions (Mechling, Ayers, Foster, & Bryant, 2015). According to the researchers, the study results suggest technological devices best serve students academically when students are trained how to operate a specific device, rather than provided with general instructions. Similar to the training required for parents and educators, students may require ongoing training and technical support to successfully use assistive technology and educational robotics (Mechling, Ayers, Foster, & Bryant, 2015).

Robotics and Disabilities

Through this literature review, it has been observed that there are numerous studies that demonstrate the benefits of using robots to facilitate social interactions for students with ASD. However, there is a lack of studies where robots are used to facilitate learning in students with low-incidence and multiple disabilities, especially in the United States. One study conducted in the United Kingdom attempts to identify ways to use a NAO to attain learning objectives and increase engagement in such students as well as methods to measure their success (Hedgecock, Standen, Beer, Brown and Stewart, 2014).

For their study, Hedgecock et al. recruited five teachers and five students as participants after giving a demonstration of the NAO robot to the school. Of the five students, three had cerebral palsy, three had epilepsy, three exhibited global developmental delay, and two were on the autism spectrum. All participants displayed severe learning and communication difficulties.

After specific learning objectives were identified (cause and effect, directionality, number recognition, and sequencing) and ways to achieve the objectives were established, the five students were videotaped during five half hours sessions interacting with the NAO robot. It was concluded that the use of the NAO robot increased engagement in all of the students with two of the students showing a significant increase in engagement. The high percentages of teacher assistance may have accounted for the increase in goal achievement.

Despite the noted benefits of robotics and technology for people with disabilities, Schdeva, Tuikka, Kimppa, and Suomi (2015) assert that people with disabilities are less likely to own a computer, have an internet connection, or utilize new technologies. The researchers refer to the gap in technological utilization between people with and without disabilities as the digital disability divide. Using a literature review research framework, the researchers systematically reviewed 4,778 conference publications and journal articles with the intent of creating a conceptual framework to analyze and potentially correct the disability divide (Schdeva, Tuikka, Kimppa & Suomi, 2015). The newly developed framework identified four key drivers of the digital disability divide, including social, technical, financial, and motivational. According to the researchers, technical barriers to technology being used by people with disabilities include a lack of software or hardware flexibility which would allow the device to be used by people with different capacities, while the social divide stems from opportunity not being offered as readily to people with disabilities, or people with disabilities being socialized to feel like they can't use new technologies.

According to Tsui, McCann, McHugh, Medvedev, Yanco, Kontak & Drury (2014), telepresence robots, or robots designed to facilitate interactions between physically present individuals and a remote user, may have positive implications for people with disabilities. Yet, telepresence is rarely designed for such individuals and often lack accessibility features which would make the technology more inclusive. For example, many telepresence robots are controlled by mouse clicks or key presses, both of which require fine motor skills which can be challenging for people with disabilities (Tsui et al., 2014). Using an interview format, the researchers determined that multiple means of navigating a telepresence robot was crucial for serving people with a wide range of disabilities. Navigation suggestions included mouse or joystick navigation, voice commands, or eye gaze navigation (Tsui et al., 2014).

In 2014, Sharkey studied the impact of robotics on care quality provided to the elderly. Though not a study of robotics in education or for people with disabilities, care robots for elderly are sometimes used to accomplish similar goals as robots used to assist people with disabilities. Like educational robots, self-care robots expand the capacity of the elderly to participate in activities which are considered necessary or commonplace. Just as participating in a classroom activity is essential to a commonplace educational experience, feeding, clothing, cleaning and caring for ones-self is crucial to an independent adult lifestyle. Sharkey asserts that, while most care providers serving the elderly are compassionate, competent, and well-meaning, there are those who do not provide the highest level of care. Assistance robots ensure that care protocols are followed and provide flexible levels of autonomy so that individuals may care for themselves (Sharkey, 2014). Though most student helpers likely provide the same high-quality assistance, expanding the ability of students to participate independently can only increase their self-sufficiency and educational opportunities.

Play, like formal education, is vital to the mental development and educational advancement of children (van den Heuvel, Lexis, Janssens, Marti & de Witte, 2017). In addition to the positive social and mental benefits of play, play-like activities are powerful educational tools for children with disabilities, but sometimes severe physical disabilities or mental disabilities make it difficult for children to participate. In a 2017 study, researchers studied the impact of an IROMEC robot on the education of children with disabilities through play-like activities (van den Heuvel, Lexis, Janssens, Marti & de Witte, 2017). The IROMEC robot is a robot which acts as a "social mediator" to give children with disabilities an opportunity to interact socially in ways which would typically be unavailable or challenging. Using observations and multiple rounds of interviews with educators, the researchers determined that the IROMEC robot improved the ability of children with disabilities to participate in play-like educational activities.

Furthermore, the robotic influence helped to facilitate communication and other interpersonal interactions between children with disabilities (van den Heuvel, Lexis, Janssens, Marti & de Witte, 2017).

Other types of “play robots” are designed to encourage play in children with a wide variety of physical and mental disabilities, while simultaneously serving as educational tools (Hawon & Eunja, 2015). For example, a research team studied the “iRobiQ” as an educational tool for children with speech-language disorders. According to the researchers, the robot provided a threefold benefit to children with disabilities, their educators, and their guardians. In addition to encouraging children with disabilities to interact through language socially, the robot provided diagnostic data to parents, professionals, and teachers. Furthermore, the robot allowed individuals involved in the treatment and education of the child to monitor progress outside of a formal classroom setting (Hawon & Eunja, 2015). As previously mentioned, robots can be useful in encouraging children with disabilities to expand their social, verbal, and physical skills by providing a low-stress environment which is educational, but fun and free of judgment or social anxiety. For children with disabilities, language communication can be particularly challenging because it includes both verbal and non-verbal cues which can easily be missed by individuals with different physical, social, or cognitive abilities. By simplifying communication at first, robots can provide long-term educational benefits (Hawon & Eunja, 2015).

According to Adams and Cook (2014), programming Lego Mindstorm robots is a useful and fun way for students to learn about science and improve students’ problem-based learning. Programming the Lego robot introduces students to STEM disciplines, which provides immediate educational benefits and future employment benefits. Children with physical and mental disabilities are sometimes excluded from such activities due to their perceived limitations (Adams & Cook, 2014). In the 2014 study, Adams and Cook used the experience of a 12-year old student with cerebral palsy as a case study for the application of Lego robots in the education of children with disabilities. Using a goal attainment scale to measure the student's ability to participate in the activity, researchers determined that the student was able to participate. Modifications were made to the lesson to allow her to use a speech generating device and customized mouse manipulation pages. Some elements of the lesson took longer due to the student's decreased mouse control, but she received educational benefits comparable to students without disabilities. The results of the study indicate that modifications to accommodate students with disabilities do not necessarily detract from educational benefits.

In 2014, Barker argued that robotics show such promise in supporting the education of children with disabilities that full curriculums utilizing robots could be developed and implemented across Europe. Prior students from the research team demonstrated that engagement of both students with and without disabilities substantially increased when robotics were integrated into classroom lessons (Barker, 2014). In order to determine the most effective application of robotics in classrooms, Barker programmed Nao robots and Lego Mindstorm robots for use by children with disabilities (Barker, 2014). According to Barker, Nao robots have a capacity to understand verbal commands and gestures, which could make communication easier for students who naturally rely on a number of communication techniques (Barker, 2014). In the study, children were filmed interacting with Nao Robots, and Barker found that the robots helped them reach educational goals in a classroom setting. Furthermore, the students' educational achievement did not wane over time as the novelty of the robots decreased (Barker, 2014).

Educational Robotics

Educational robotics are hands-on learning tools that allow teachers to create learning environments that are collaborative, creative, and foster communication among students. Within the past ten years, teachers have viewed robotics as an effective tool in the development of problem-solving and social skills for students from pre-school to high school (Alimisis, 2013). Participants in this research study utilized four different educational robotics: Sphero, Ozobot, Beebot, and Dash.

Created in 2010 by Colorado company Sphero (formally Orbotix), Sphero is a spherical robot toy about the size of a baseball that is wrapped in polycarbonate plastic and is capable of rolling around, changing colors, running programs, and being controlled by a smartphone or tablet through Bluetooth. Sphero is an affordable way to fuse robotics and digital technology into immersive entertainment experiences that ignite imagination and defy expectation (Sphero connected entertainment robots, n.d.). Students are instantly engaged by witnessing the immediate reaction of their robot and are able to reflect on their learning and "generate new ideas for what's possible between a program, a robot, the physical world, and their imagination" (Sphero breaks the rules with new SPRK bot - Yahoo Finance, n.d.).

Ozobot, winner of the 2015 Kids at Play Interactive (KAPi) award for Best Robot, "is a smart robot that teaches kids how to code, engages them in deductive reasoning, and gives them a greater understanding of robotics overall" (Barba, 2015). Available in two models, the original ozobot can follow lines, detect colors, and can be programmed using visual color codes or can be programmed using the Ozogroove app. By merely drawing color-coded line patterns called "OzoCodes," OzoBot is programmed to associate specific movements with specific colors, allowing students to work on STEM/STREAM applications through hands-on robotics and programming applications.

The Ozobot Bit, which offers all of the functionality of the base Ozobot model, incorporates a block-based programming editor called OzoBlockly which affords students the ability to fully control its behavior. With Ozobot Bit, "students can make the natural progression from visual coding into the world of block-based programming" making this robot suitable from Kindergarten through high school (Ozobot teachers guide, n.d.).

Created by Terrapin Inc., the Bee-Bot is a bee-shaped robot designed for use by young children. With its sturdy construction and colorful design, the Bee-Bot is an excellent tool for teaching sequencing, estimation, and problem-solving. Directional keys and a "go" button are located at the top of the robot and can be used to enter up to 40 consecutive directional commands. The Bee-Bot will blink and beep at the conclusion of each command to allow children to follow Bee-Bot through the program they have entered. After the Bee-Bot has performed the set of commands, it will confirm its completion with lights and sound (Bee-Bot teachers guide, 2017).

Dash, a three-legged motorized robot created by Wonder Workshop, is an app-enabled robot which can be controlled by a tablet or phone via Bluetooth. Dash has a variety of sensors and capabilities which allow it to respond to voices, avoid obstacles, light-up and make a variety of sounds. The Go app allows Dash to be controlled directionally like a remote-controlled car. The Blockly app allows the user to create block codes that can be sent directly to Dash. Additional accessories, such as a xylophone and launcher can be added to Dash for added learning opportunities.

Schools for Students with Disabilities

Finally opening its doors on September 22, 1931, former Jersey City Commissioner and New Jersey Governor, Arthur Harry Moore was instrumental in the construction and naming of the A. Harry Moore School. Originally named the A. Harry Moore School for Crippled Children, this Jersey City, NJ school was one of the first in the nation to provide a public education for physically disabled children.

Through the efforts of Dr. Henry Snyder, Superintendent of Schools, Mayor Frank Hague and legislation passed by Governor A. Harry Moore in 1925 authorizing the building of schools especially adapted to specialized education for crippled children, a small building near City Hospital was utilized. When this original building became part of the Medical Center, Mayor Hague and the Board of Education planned a new a better facility. Ground was broken in October 1930, and the new school was completed in September 1931. This school, then known as Public School No. 36, was the first public school to be erected in the United States “expressly and solely for crippled children.” On May 5, 1931, before a crowd of 5,000, former Governor A. Harry Moore assisted by Mayor Frank Hague and President Franklin Delano Roosevelt laid the cornerstone of the school that would eventually bear his name.

The A. Harry Moore school offered unique, innovative and specially designed features and programs to its students. The specially designed school included elevators, handrails in corridors and classrooms, adjustable seats and desks, wheelchairs, and a solarium. The school offered specifically designed treatment rooms for corrective surgery and a swimming pool for aquatic therapy. The school offered courses in watchmaking, sewing and general domestic science as well as their regular academic subjects, occupational, physical and speech therapy services. It's use of assistive technologies made the school groundbreaking for its time.

The A. Harry Moore School was part of the Jersey City Public School system until 1962 when Michael B. Gilligan, President of Jersey City State College, suggested its transfer from the Jersey City Board of Education to the State of New Jersey. Under the direction of then principal Agnes Thompson, A. Harry Moore became the teaching laboratory school for Jersey City State College students majoring in the expanding field of special education. These students not only took classes and spent countless hours studying at A. Harry Moore but also extended their learning experience into the summer at the A. Harry Moore Camp at High Bridge.

Today, New Jersey City University (NJCU), formerly Jersey City State College, leases the school from the Jersey City Board of Education. Funding for the operation of the program comes from local sending school districts and the Department of Education, through its relationship with NJCU and funding from the federal government.

The school currently offers a comprehensive educational and medically related program for its 120 preschool, orthopedically, cognitively and multiply disabled students aged 3-21. The faculty consists of 49 professionals including teachers, therapists and administrators fully trained in special education. Many of the faculty members have advanced degrees or training in their individual disciplines. Also, the school has approximately 40 ancillary staff that includes program and teacher aides, clerical staff, food service workers and maintenance personnel. A comprehensive therapeutic program is offered including physical therapy, occupational therapy, speech therapy and music therapy as well as many medically related services.

The capacity to include students with disabilities in the public educational school system has improved dramatically since 1931. In 2016, Zhuhadar, Carson, Daday, Thrasher, and Nasraoui discussed the concept of "smart schools," and how they can revolutionize education for students with disabilities. The researchers argue that as inclusion in the workplace increases, it will be more critical for students with disabilities to have access to the same educational opportunities as non-students with disabilities, in addition to being familiar with the types of assistive technologies which are available to them in the classroom and workplace. Schools can become more inclusive by fully utilizing technology which is already widely available, like audio and video recording lectures. Technologies such as the Universal Video Captioning platform (UVC) increase the ability of students to benefit from in-class lectures, even if they are unable to attend class physically (Zhuhadar, Carson, Daday, Thrasher & Nasraoui, 2016). UVC platforms are particularly important for educating students with disabilities in STEM disciplines, as many students benefit from in-class demonstrations of problem solving, formulas, and mathematics.

When considering how to optimize schools to improve educational outcomes for students with disabilities, research suggests that both students with and without disabilities could benefit from multiple learning modalities (Tschannen-Moran, Uline, Hoy & Mackley, 2000). By engaging in an interactive school improvement process, learning outcomes for all students could be improved by the application of appropriate techniques and technologies which may be particularly helpful to students with disabilities. In 2000, Tschannen-Moran, Uline, Hoy, and Mackley asked how schools could be "smarter," even before conversations emerged about smart cities and the application of modern technological innovations. Applying lessons from cognitive science to educational design, the researchers used a high school in the Midwest as a case study for the creation of smarter schools. Among other key observations, the researchers determined that learning is a highly social activity for students and that many students learn more easily from their classmates than from books or formal instructors (Tschannen-Moran, Uline, Hoy & Mackley, 2000). This lesson is particularly relevant to the education of students with disabilities in that it suggests the potential value of technological innovations which allow students with disabilities to interact with other students and fully participate in a collaborative educational environment.

In 2017, Jain and Chavan argued that technological improvements in academic settings can improve learning attainment in both students with and without disabilities, suggesting that improving the educational options for students with disabilities need not be seen as a task separate from educating students in general. For example, Jain and Chavan found that using "smart board" technologies improved the capacity of students with disabilities to learn STEM disciplines. In the study, half of the students with mild to moderate mental disabilities were taught a science lesson by their regular teacher in a regular classroom without smart boards. The second group of students was taught the same material, except they used the "smart board." The researchers found that students who were taught on the smart board made significant progress in learning the lesson compared to their peers who were taught in a typical academic environment (Jain & Chavan, 2017).

Similar to the previous discussion on the role of teachers and faculty in using technology to assist students with disabilities, the implementation of smart schools requires teacher and faculty to take on a greater technological burden (Ibrahim, Razak, Kenayathulla, 2013). The widespread usage of ICT is often considered a crucial element of smart schools, and therefore faculty members will be required to operate technology which may not have been part of their formal educational training burden (Ibrahim, Razak, Kenayathulla, 2013). Ibrahim, Razak, and Kenayathulla (2013) assert that creating smart classrooms will require training, IT support, and ongoing instruction for both students and teachers as technologies change and student needs alter.

Chapter Summary

Numerous studies suggest that assistive technology positively benefits the educational achievement of students with disabilities (Soorenian, 2014; Sachdeva, Tuikka, Kimppa, Kai & Suomi, 2015; Vidacek-Hains, Kozina & Kirinic, 2016). In many cases, assistive technology allows students with physical and mental disabilities to participate more fully in educational lesson programs designed to serve both students with and without disabilities by facilitating minor customizations such as mobility assistance or compensating for visual or auditory impairments. Despite the noted educational benefits of assistive technology, successfully implemented assistive technology in classrooms requires training for both students and faculty (Basak & Govender, 2015). Assistive technology can be challenging to navigate for individuals who are unused to using technology in a classroom setting, and even trained users often need ongoing technical assistance as issues arise (Basak & Govender, 2015). Furthermore, students with disabilities often need training and instruction customized to a particular device, rather than generalized instructions (Mechling, Ayers, Foster, & Bryant, 2014).

While assistive technology allows students with a wide range of disabilities to more fully participate in generalized classroom lessons, robotics can offer an opportunity to tailor educational experiences directly to the needs of students with ASD (Aresti-Bartolome & Gracia-Zapirain, 2014). Human-like robots can facilitate lessons which help students with ASD gain confidence socially while tracking educational and social progress in a stress-free environment (Alley-Young, 2016). Using robotics to educate students with ASD is still a relatively new phenomenon, and challenges arise in developing technology capable of interpreting or expressing human emotion (Cominelli, Carbonaro, Mazzei, Garofalo, & Tognetti, 2017). However, robotics have a positive implication for the education of students with ASD, particularly because studies suggest that students with ASD are disproportionately interested in STEM disciplines, suggesting that an early introduction to the sciences could further their long-term academic interests (Wei, Yu, Shattuck, McCracken, & Blackorby, 2013).

Robotics has a wide range of educational applications for people with disabilities in general, including options for mobility-limited individuals or individuals with mental impairments (Tsui, McCann, McHugh, Medvedev and Yanco, 2014). Telepresence robots, or robots which provide a physical presence to remote users, can be useful in improving the social engagement of individuals who are unable to attend educational opportunities in person. Furthermore, robots can increase the independence of students with disabilities by allowing them to function independently from caretakers and participate more fully in educational opportunities (Sharkey, 2014). Finally, numerous studies suggest that robots designed to facilitate learning through play can increase the educational achievement and enjoyment of students with a wide range of physical and mental disabilities (van den Heuvel, Lexis, Janssens, Marti & de Witte, 2017).

Collectively, implementing robots and assistive technology can help to create a smarter school environment. Technologically advanced schools, referred to as "smart schools," can result in greater educational achievement for students with and without disabilities (Zhuhadar, Carson, Daday, Thrasher & Nasraoui, 2016). By utilizing multiple educational modalities, smart schools can provide students with an opportunity to learn in a way which is most effective for them. Video recorded lessons, "smart boards" and mobile applications allow students to review materials which were challenging to them or review information which was missed due to physical or mental impairments (Tschannen-Moran, Uline, Hoy & Mackley, 2000). Technological improvements in schools can improve learning attainment in both students with and without disabilities, suggesting that educating students with disabilities need not be seen as a task separate from educating students in general (Jain & Chavan, 2017).

Chapter III: Methodology

Introduction

Teachers and therapists at the A. Harry Moore School have been recognized for their work with educational robotics and students with low-incidence disabilities (Pepe, 2015, 2016). This exploratory case study evaluated teacher, therapeutic and administrative knowledge, implementation and perception of the use of robotics for students with disabilities in a specialized school setting. Universal Design for Learning, which is a teaching and learning framework that helps to ensure that every child has a learning experience that is multi-dimensional, multi-sensory, significant, and exciting (Brand & Dalton, 2012), is the underlying theoretical framework of this study. Based on this framework, the researcher explored how teachers and therapists utilize the principles of UDL to implement robotics into the learning environment and consequently recorded their perceptions of student level of engagement. The researcher sought to find significance in the views and experiences of the teachers, therapists, and administrators of the A. Harry Moore School who were selected for their innovative use of robotics for students with low-incidence disabilities. This chapter provides a rationale for the qualitative case study design as well as detailed information on the study's philosophical framework, methodology, and participants. The results contribute to the understanding and best practices for robotic implementation.

Interpretive Framework

The worldview a researcher adopts influences the research method used in a study (Creswell, 2014). For this qualitative study, a constructivist philosophical framework was used. Through this philosophical lens, the researcher sought to construct meaning from the interactions and observations of the participants by carefully interpreting the data collected (Creswell, 2014, p. 8). Through open-ended interviews and classroom observations, the researcher attempted to contribute to the body of knowledge needed to address how the use of robotics can support the education and therapeutic goals of students with low-incidence disabilities.

Rationale for a Qualitative Study

Qualitative research is a method of inquiry "that helps us understand and explain the meaning of a social phenomena with as little disruption of the natural setting as possible" (Merriam, 1998, p. 5). The purpose of qualitative research does not only involve recording the details of events but also uncovering how these events affect not only the participants but the onlookers. From an educational perspective, qualitative research was particularly useful when detailed information is needed about a specific implementation (Erickson, 2012). For this qualitative study, teacher, therapist, and administrative knowledge, experience, and implementation of robotics were explored through observations and interviews.

Rationale for a Case Study

For this qualitative study, the researcher used an exploratory case study design. Yin (2013) stated that case studies are used when the researcher is exploring the "how" and "why" of a question, is studying a present-day issue, and when the researcher does not have control over the results. Collecting data in multiple forms and spending a significant length of time gathering data in the "natural setting" were the characteristics of a qualitative study (Creswell, 2014). The researcher in this study was trying to discover if the use of robotics could support the educational and therapeutic goals of students with low-incidence disabilities.

Research Questions

This study focused on the following questions:

1. What role does administration play in successful school-wide robotics implementation?
2. How do teacher's and therapist's knowledge and implementation of robotics influence the attainment of educational and therapeutic IEP goals for students with low-incidence disabilities?
3. What patterns emerge in the experiences and perceptions of teachers, therapists, and administrators during the implementation of robotics as an educational and therapeutic tool for students with low-incidence disabilities?
4. What principles of UDL are represented by the implementation of robotics into curricular activities for students with low-incidence disabilities in their classrooms?

Context

This study took place at the A. Harry Moore School in Jersey City, New Jersey. A. Harry Moore is a school for students with low-incidence disabilities aged 3-21. Students are sent to A. Harry Moore school when their home school district does not have a program to meet their unique physical, educational and therapeutic needs. The school has approximately 102 students with various low-incidence disabilities. Student home districts include Jersey City, Bayonne, Hoboken, West New York and Carteret.

Researcher's Position

The researcher was the technology coordinator at the A. Harry Moore School of New Jersey City University (NJCU) and a doctoral candidate at NJCU's Educational Technology Leadership program. She has held the position of technology coordinator for the past 13 years. Prior to holding the position of technology coordinator, she spent 13 years as a classroom teacher at the A. Harry Moore School.

Participants

The target population for this study was composed of teachers, therapists, and administration from the A. Harry Moore School in Jersey City, New Jersey, which is a school for students with low-incidence disabilities. These different individuals were chosen as part of the target population because they are directly involved in the decisions and implementation related to the interventions in classrooms, especially for students with low-incidence disabilities. Therefore, these individuals had the knowledge and perceptions that are relevant to addressing the research questions of the study.

A convenience sample of 23 teachers, 14 therapists and three administrators of students with low-incidence disabilities working at A. Harry Moore were selected. After receiving IRB approval, the researcher contacted the principal of the school for permission to conduct the study with the 37 faculty members. The researcher then sent an email to all teachers, therapists, and administrators asking them if they would like to participate in the observations and interviews. A total of 6 teachers, three therapists, and two administrators agreed to participate in the study. After consent, the researcher contacted each of the consenting participants to schedule an interview time.

Data Collection

Recruitment process. Approval was granted by the Institutional Review Board (IRB) of New Jersey City University to conduct this study and ensure fair and ethical treatment of the study participants (Appendix A). Approval was then granted by the Provost of New Jersey City University (Appendix B), the Dean of the Deborah Cannon Partridge Wolfe College of Education at New Jersey City University (Appendix C) and the principal of the A. Harry Moore School in Jersey City, New Jersey (Appendix D) for permission to conduct the study and contact the classroom teachers and therapists. A subsequent email was sent to all A. Harry Moore School teachers and therapists requesting participation in a pre-observation interview, an observation of a lesson or therapeutic session where robotics were being used for instructional or therapeutic purposes, and a post-observation interview (Appendix E). Although the participants observed in this study consisted of classroom teachers and therapists, a letter informing parents of the focus of the study and nature of the observations was sent to all students at the A. Harry Moore School (Appendix F).

Data collection process. In this study, two types of data were collected: observational data that was recorded using field notes and observation protocols, and interviews that were transcribed from teachers, therapists and the building administration. As per Gray (2009), “Observation involves the systematic viewing of people’s actions and recording analysis, and interpretation of their behavior” (p. 397). Field notes were recorded, and an observational protocol was used during the observation phase in an attempt to record teacher knowledge, innovative experiences, and implementation styles, and the UDL principles utilized (Appendix H). Creswell (2014) recommends that the observation protocol must include both the date and length of the observation as well as a place to record both reflective and descriptive annotations.

The researcher conducted interviews in two phases: before and after the observation with teachers and therapist in the chosen school. The interviews were conducted after obtaining permission from the principal and receiving the copies of the signed informed consent forms from the participants. Teachers and therapists in the school were interviewed before and after the observations to provide input into the views of educational professionals, who have the relevant knowledge and experience, about robotics implementation for students with low-incidence disabilities. Both the pre- and post-observation interviews used a semi-structured format. In semi-structured interviews the researcher had a predetermined set of questions, though, follow-up questions may be asked (Fylan, 2005). The interview questions for the post-observation were not fully determined until after the observation as to fill in gaps needed to create a complete overview.

Pre-observation interview. The purpose of the pre-observation interview was to provide the researcher with background information on how and why robotics will be integrated into the lesson, the targeted IEP goal, and the amount and type of professional development provided to the teacher or therapist. For the pre-observation interview, the questions were focused on obtaining information about the background of the participant in relation to professional development and technological (e.g., robotics) intervention for students with low-incidence disabilities. The researcher used an interview protocol as a guide in conducting the interview (Appendix G). The pre-observation interview began with an introduction, which is an informative discussion of the background of the study and the interview process. After the introductions, 14 questions were asked about the background and implementation of interventions for students with low-incidence disabilities. The interview was semi-structured; therefore, the researcher asked follow-up questions when necessary in order to gain a deeper understanding into the answers of the participants. Any comments and questions from the participants were discussed during the last part of the pre-observation interview. At the end of the pre-observation interview, the researcher thanked the participant for allotting time to answer the questions.

Observations. The researcher conducted observations of teachers and therapists in order to obtain a firsthand encounter of the phenomenon being studied (Merriam, 1998). The purpose of the observations was to provide the researcher additional information on innovative robotics implementation and what UDL principles were being represented by the use of robotics. Yin (2013) stated that observations are invaluable aids for understanding the actual uses of the technology or curriculum and any problems being encountered. The observations also provided the basis for a more comprehensive discussion during the post-observation interview.

During the observation, the researcher used an observation protocol (Appendix H) as a guide when taking note of significant actions, details, and ideas that were present during the session. The researcher took descriptive notes that were focused on detailed discussion of relevant observations. The researcher also took reflective notes, which were interpretations that support the descriptive notes and observations. Finally, the researcher also identified and described the physical setting, description of the activity, UDL guidelines used, and the educational and therapeutic goals associated with the observation session.

Post-observation interview. During the post-observation interview, the teacher/therapist was asked a question about the researcher's observations. The researcher used a post-interview protocol (Appendix I) as a guide when asking questions from the participants. The post-observation interview allowed the teacher/therapist to elaborate on how lessons or therapy sessions were prepared and why certain instructional/therapeutic decisions were made. The post-observation interview also allowed teachers and therapists to expand upon their concerns, obstacles, and successes with robotics implementation and elaborate on the UDL principles observed by the researcher. Interviews were also conducted with building administrators to ascertain their role in school-wide robotics implementation, including any obstacles, concerns or policy changes that may have been made (Appendix J). Aside from interpretations, the reflections also included questions to self and observations of nonverbal behavior.

Interviewing provides information and feelings that cannot be observed (Merriam, 1998). Yin (2013) recommended open-ended interviews to increase the complexity of the data being obtained. Through these observations and interviews, the researcher attempted to explore and describe the innovative use of robotics in a school for students with low-incidence disabilities. These descriptive examples will help guide other special education teachers to integrate robotics into their classrooms.

Data Organization and Analysis

Data organization. After conducting the data collection phase, the researcher transcribed each interview session. The researcher labeled each transcript with the pseudonym for the participants to keep their respective identities confidential. After transcribing the interviews, the researcher performed member-checking, wherein the participants can review their interview transcripts to discuss any need for changes with the researcher (Birt, Scott, Cavers, Campbell, & Walter, 2016). Through this process, the credibility of the data has been improved. The researcher finalized the transcripts after member checking. The researcher also made a word-processed copy of the observation notes. The researcher then loaded the final copies of the transcripts and the observation files to the NVivo software.

Data analysis. The researcher used Yin's (2013) five-phased cycle for coding case study data. The coding process included the following phases: (a) compiling; (b) disassembling; (c) reassembling; (d) interpreting; (e) concluding. The compiling phase referred to the data organization process mentioned in the previous section. Also included in the first phase, the researcher wanted to be familiar with the data by reading and re-reading the texts from interviews and observation notes. After familiarization, the researcher performed disassembling, which involved breaking down the data into smaller codable words, phrases, sentences that were relevant to the research questions of the study. The researcher then assigned new labels or *codes* to each of the relevant fragments or pieces of information from the transcripts and observation notes. In the third phase, the researcher clustered similar codes into relevant groups to form themes (Yin, 2013). In the fourth phase, the researcher used the grouped data to develop a narrative of the overall interpretation of the data. In the fifth phase, the researcher developed conclusions and presented recommendations based on the findings (Yin, 2013).

Ethical Considerations

The confidentiality and identity of the participants are kept protected. The researcher used pseudonyms to replace the names of the participants. Interviews were kept under 45 minutes and observations were dependent upon the length of the robotics infused lesson being presented. Letters/emails sent to potential participants included the anticipated time commitment. The researcher provided the participants copies of the transcripts and observational notes for clarification purposes. The researcher kept all the copies of the interview transcripts, observation notes, audio recordings, and consent forms on a secure flash drive. All the data and information were kept on the password-protected flash drive for five years. The flash drive will be kept inside a locked cabinet in the researcher's home office, together with printed materials that were used for the study, such as informed consent forms, hand-written notes, and letters. All the physical data will be destroyed while the electronic data will be permanently deleted after five years of storage.

Standards of Quality

For qualitative case studies, ensuring the quality of data meant improving the trustworthiness of the findings (Lincoln & Guba, 1985). Trustworthiness has four main components: credibility, dependability, confirmability, and transferability (Lincoln & Guba, 1985). To improve credibility, the researcher performed member checking (Birt et al., 2016). Through the process of allowing participants to review the transcripts, the researcher ensured that the data are based on the actual intended meaning of the participants instead of the personal interpretations of the researcher alone. To improve transferability, the researcher provided a detailed discussion of the findings of the study and the process used to implement the methodology and research design (Lincoln & Guba, 1985). Through this discussion, future researchers can easily determine if the findings may be transferable or applicable to other settings or contexts (Lincoln & Guba, 1985). To improve the dependability of the findings, the researcher generated an audit trail of the documents and procedures used (Lincoln & Guba, 1985). Finally, to improve confirmability or data objectivity, the researcher ensured that the data is based on the actual experiences or perceptions of the participants or the members of the target population. Therefore, personal biases and expectations were initially acknowledged before conducting any data collection and analysis procedure to minimize being influenced by these biases while completing the study.

Chapter Summary

This chapter summarized the methodology for the exploration of the innovative integration and best practices of robotics at the A. Harry Moore School. An exploratory case study design was used for this research. The target population for this study was composed of teachers, therapists, and administration from the A. Harry Moore School in Jersey City, New Jersey, which is a school for students with low-incidence disabilities. A convenience sample of 23 teachers, 14 therapists and three administrators of students with low-incidence disabilities working at A. Harry Moore were selected. The researcher contacted the principal of the school for permission to conduct the study with the 37 faculty members. The study used observations and interviews to capture the views and practices of the teachers and therapists who integrate robotics into their lessons and therapeutic sessions. Data were analyzed using Yin's (2013) five-phased cycle for coding case study.

Chapter IV: Findings of the Study

Introduction

The purpose of this exploratory case study was to discover how the use of robotics can support the educational and therapeutic goals of students with low-incidence disabilities. The following four research questions were used to guide the study:

1. What role does administration play in successful school-wide robotics implementation?
2. How do teacher's and therapist's knowledge and implementation of robotics influence the attainment of educational and therapeutic IEP goals for students with low-incidence disabilities?
3. What patterns emerge in the experiences and perceptions of teachers, therapists, and administrators during the implementation of robotics as an educational and therapeutic tool for students with low-incidence disabilities?
4. What principles of UDL are represented by the implementation of robotics into curricular activities for students with low-incidence disabilities in their classrooms?

Chapter IV includes a description of the cases (i.e., administrators, therapists, and classroom teachers) that were explored, followed by a description of the implementation of the data analysis method described in chapter III. Next, the chapter proceeds with a presentation of the findings of the study. The chapter concludes with a summary of the findings.

Description of the Cases

For this study, the researcher conducted one-on-one, semi-structured interviews with six teachers, three therapists, and two administrators, and observations with the therapists and teachers, to gain an understanding of how robotics are used at the A. Harry Moore School and the impact they have on student educational and therapeutic goal achievement. Table 1 describes the participants in this study. Pseudonyms were used to protect the identity of the research participants.

Table 1

Description of Participants

Participant	Years at AHM	Highest Degree Achieved	Grade Taught/ Therapy
Preschool Teacher Emma	25	MA Special Education	Preschool – Ages 3-5
Teacher Natalie	32	MA Educational Technology	All Grades – Ages 3-21
Primary Teacher Allison	22	MA Special Education	Primary – Ages 5-7
High School Teacher Sarah	5	MA Special Education	High School – Ages 15-18
Middle School Teacher Charlotte	24	MA Educational Technology	Middle School – Ages 11-14
Teacher Denise	29	MA Educational Technology	All Grades – Ages 3-21
Occupational Therapist Andrea	26	MS Occupational Therapy	Occupational Therapy
Speech Therapist Olivia	9	MS Speech-Language Pathology	Speech Therapy
Physical Therapist Elizabeth	4	Doctor of Physical Therapy	Physical Therapy
Administrator Kimberly	2	Ed.D Educational Leadership	None
Administrator Ken	10	MA Administration and Supervision	None

Table 2 outlines the specific robotic activity presented by the teacher or therapist and observed by the researcher.

Table 2

Description of Robotic Activity

Participant	Subject	Robot	Subject of Lesson
Preschool Teacher Emma	Social Studies	Ozobot	All About Me
Teacher Natalie	Science	Ozobot	Circulatory System
Primary Teacher Allison	Math	BeeBot	Number Recognition/ Addition & Subtraction
High School Teacher Sarah	Geography	Dash	State Identification
Middle School Teacher Charlotte	History	Sphero	Passage of the Mayflower
Teacher Denise	Recreation	Sphero/ Dash	Bowling
Occupational Therapist Andrea	Fine Motor Skills	Ozobot	Handwriting without Tears
Speech Therapist Olivia	Verbalization	Ozobot	Sequencing
Physical Therapist Elizabeth	Power Chair Training	Dash	Obstacle Course

Classroom Teacher Participants

Preschool Teacher Emma: The first participant interviewed and observed (Preschool Teacher Emma) has been a teacher at A. Harry Moore for 25 years. While she has taught many different age groups over her career, she is currently teaching a preschool class of students aged 3-5.

During her pre-interview, Preschool Teacher Emma indicated that she had used robotics a few times in the computer lab but had not used them in the classroom yet this school year. When asked her thoughts and opinions on implementing robots into her lessons she stated, “I’m excited. I think that the kids really can benefit from using robotics in the classroom” (Preschool Teacher Emma, pre-interview, 11/7/2017). Her educational and IEP goals for robotic implementation and her specific lesson included: increasing student ability to engage in the lesson, taking turns, making eye contact and identifying oneself. She explained that she uses the 2014 Preschool Teaching and Learning Standards when planning her lessons and that her lesson would be addressing Preschool Standard 6.1.1: Describe characteristics of oneself.

When the researcher observed Preschool Teacher Emma, she was presenting a social studies lesson entitled “All About Me.” In this lesson, the teacher showed the students a digital book on an iPad. The title of the book was “I Am Me.” After she played the digital book two times, she showed each child a picture of themselves. Hand over hand she had the child touch their own chest and say “I am…..(student’s name).” Then she put a mirror in front of each child and repeats “I am…..(student’s name).” Next, she places the child’s picture at the top of a piece of white paper. Hand over hand she helps the student draw a line from the bottom of the paper to their face. For this activity, the teacher chose to use small robots called Ozobots (see Figure 1). Each student was asked to point to the picture of their face then place the Ozobot on the line at the bottom of the page. The teacher states, “The Ozobot is going to find…….(student’s name).” The students were encouraged to watch the Ozobot find his/her own face.

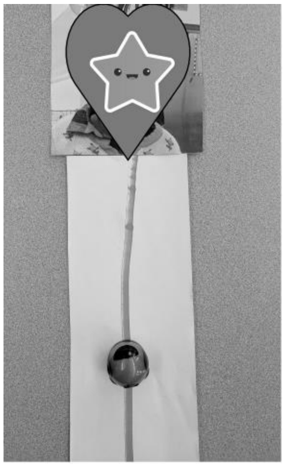

Figure 1. I Am Me Activity with Ozobot.
The photograph has been altered to protect the identity of the student.

During the post-observation interview, the researcher reviewed her observation notes with the teacher for clarification. Preschool Teacher Emma stated that her educational and IEP goals for this lesson were to have the students identify themselves in a picture and practice fine motor skills and hand-eye coordination by picking up and placing the Ozobot on the line. She also stated that some of her students also benefitted from visually tracking the Ozobot as it traveled along the line to the student's face. Preschool Teacher Emma explained that they try to identify themselves on a daily basis by pointing and looking in a mirror but explained, "I think the robots help to enhance the process and the kids were really excited to use the robots" (Preschool Teacher Emma, post-observation interview, 11/8/2017).

In planning for her lesson, the participant said that she printed out pictures of her students, borrowed the Ozobots from the Technology Coordinator and made sure they were charged. She prepared long strips of white paper and collected some "fat markers." She said she also found the story on her iPad that she pre-read with the students before starting the lesson.

When asked if the lesson went as planned, the teacher stated, “Yes, overall the lesson went as I planned, however, I was trying to be quick enough so the students didn’t put the Ozobot in their mouth” (Preschool Teacher Emma, post-observation interview, 11/8/2017). “Being that it’s small and it lights up and vibrates it was very intriguing to them” (Preschool Teacher Emma, post-observation interview, 11/8/2017). While the lights and vibration added to the appeal and helped the students stay engaged in the lesson, it also caused the three and four-year-old students to want to explore them further tactilely.

When asked about the constraints that affect robotic implementation in Preschool Teacher Emma’s classroom, she stated that the biggest constraint was time. “The demands of the schedules, students being pulled in and out for therapies and for specials throughout the day and having the time to train my staff,” she stated (Preschool Teacher Emma, post-observation interview, 11/8/2017). Preschool Teacher Emma did state that she finds value in the use of robotics in her lessons explaining that she thinks they add excitement to the lesson and enhance the learning process.

Teacher Natalie: The second teacher to participate in the study was a veteran teacher with over 30 years of experience teaching students with low-incidence disabilities at the A. Harry Moore School. Teacher Natalie also has taught many different age groups at the school. Her background for robotic implementation began about three years ago when introduced to Sphero by a new administrator to the building. She stated that she felt the robotics would blend well with her science and math curriculum.

> I’m able to use it in a variety of different ways to help the students have a different means to actually examine and explore topics that their peers, who are

> non-disabled, are also exploring. It gives them a means to have multiple ways of access to the topic and it actually gives them a greater means of engagement, she explained (Teacher Natalie, pre-interview, 11/13/2017).

After first introducing Sphero to her class during one of her science lessons, Teacher Natalie was amazed how engaged the students were by the lesson. She described being overwhelmed by the fact that her students, who usually have difficulty with engagement, eye contact, and visual tracking, were now “following a robot as it crossed the floor.”

> So I think that was really what turned my head for me at the time and made me want to use robotics more, because I saw that our students were really in need of anything that would allow them to focus and give them another means to have access to a topic. (Teacher Natalie, pre-interview, 11/13/2017).

Since that time, she has tried to integrate robotics as much as possible.

The educational objectives and IEP goal for robotic implementation for Teacher Natalie stem from the Next Generation Science Standards and Core Curriculum Content Standards for math that she is trying to address during her lesson planning. So whether it is using the Ozobots to follow a system in the body or it is Sphero because she is doing some coding, her objective is for the student to use the robotics as a support to gain the information that is provided by the standard. “So everything hopefully unites,” she stated. “You have the standard, you have the science topic, and the robotics works as a way to implement all of that to work” (Teacher Natalie, pre-interview, 11/13/2017).

The lesson that the researcher observed was an expansion of a previously taught lesson on the circulatory system. Teacher Natalie explained that she had done lessons similar to this where she had students use different things to follow the circulatory system, things that didn't move, but she felt that the students were more engaged with the use of robotics. "And I think that [robotics] helps them retain more information" (Teacher Natalie, post-interview, 11/14/2017). The participant used Ozobots to demonstrate how oxygenated blood moves from the heart throughout the body and then after the oxygen is depleted from the blood how it moves back to the heart to be pumped to the lungs. She chose this lesson to meet Next Generation Science Standard HS-LS1-2: Develop and use a model to illustrate the hierarchical organization of interating systems that proide specific functions with multicellular organisms.

For this lesson, the teacher put a life-size outline of a human body on the table. The teacher drew the outline prior to the lesson. She explained to the students that they were going to track the movement of oxygenated blood to and from the heart and lungs reminding them of the previous lesson where they talked about the circulatory system. While drawing lines on the body, she explained that the red lines from the heart to the extremities represented the blood that was pumped from the heart and the blue lines represented the blood that returned to the heart. She brought out the Ozobots, which were borrowed from the technology department, and told the students that the robot would be representing the oxygenated blood that would travel throughout the body and back to the heart and lungs (see Figure 2). The Ozobot turned blue when traveling on the blue lines and red when traveling on the red lines. The teacher asked for volunteers and had each student take turns placing the Ozobot on the body and explaining what was happening. Non-verbal students were asked Yes/No questions and used non-verbal cues or communication devices to answer questions.

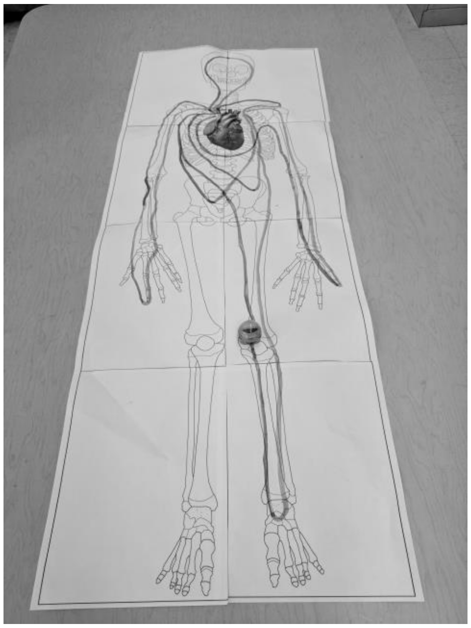

Figure 2. Circulatory System with Ozobot

After the observation, the researcher conducted a post-observation interview with the participant. The participant reiterated that her educational goals for this lesson were to have the students understand the path that blood travels from the heart throughout the body and back through to the heart. Her additional goals also included following directions and collaboration. She stated that the lesson did go as planned with the exception of the few minutes "where the Ozobot decided not to follow the circulatory system and the students got a little bit flustered" (Teacher Natalie, post-interview, 11/14/2017).

When asked if she found value in the use of robotics with her students, Teacher Natalie stated:

> I do. I'm definitely pro using technology, and I've seen the difference that it has made, and I think that it makes the students have more opportunity to be part of the lesson. I think that lessons should be hands-on, students should be doing, they shouldn't be just listening, they should be the doers. I'm here to provide basic

information, and they should actually be an active participant in their learning. Robotics helps you do that. (Teacher Natalie, post-interview, 11/14/2017)

While Teacher Natalie sees time as one of the constraints to robotic implementation within her classroom, she also states that "the more you use robotics, and the more you integrate robotics into your lessons, the easier it is and the more seamless it becomes" (Teacher Natalie, post-interview, 11/14/2017).

One of the biggest factors that influenced the use of robotics in Teacher Natalie's classroom was having a core group of colleagues who share the same interests. She stated that "the use of robotics excites people and I think that when you have other colleagues who see what you're doing, and they're interested in it, I think it creates a snowball effect" (Teacher Natalie, post-interview, 11/14/2017). That coupled with the enthusiasm of the students, some of them who are very physically involved, blends together to make robotic use have an important purpose.

Primary Teacher Allison: The third study participant has been a teacher at A. Harry Moore for approximately 22 years. During those 22 years, she has primarily taught students with low-incidence disabilities between the ages of five and nine. Her current students are aged five to seven and have IEP goals and objectives that range from the Kindergarten to Second Grade level. Her interest in robotics stemmed from watching her colleagues use robotics with their students and getting their input on how to best implement them for her particular students.

When asked about her thoughts and opinions about implementing robotics into her lessons, Primary Teacher Allison she stated that she thought robotics was a good way to motivate the students, keep them engaged and give them options. She also said, "it's good for me too because I am continuously teaching the same concepts and I would get bored, you know, learning to identify numbers or whatever the topic is, so I know they get bored with the same old lesson" (Primary Teacher Allison, pre-interview, 11/14/2017).

Primary Teacher Allison's main educational goals for robotics implementation is being able to differentiate instructions for her students. She stated that "robotics allows me to differentiate the lesson but allow for all the students to still do the same activity" (Primary Teacher Allison, pre-interview, 11/14/2017). Additional goals include: maintaining attention, following directions and comprehending the questions that are asked during the lesson, listening, sitting still and taking turns. She has also seen an increase in their educational goal achievement since implementing robotics. "They function better as a group, they are more willing to take turns, and they're learning from one another," she explains (Primary Teacher Allison, pre-interview, 11/14/2017). The participant also feels that the use of robotics keeps the students motivated and engaged in the lesson.

For Primary Teacher Allison's observation, she presented a math lesson using the BeeBot. She explained that she had introduced the lesson earlier in the week and this lesson was a way to reinforce the previously taught concept of reading number sentences and performing simple calculations. In this lesson, the higher level students worked to solve simple number sentences while the lower level students worked on simple number recognition. She stated that for lesson planning and IEP goal achievement, she was focusing on the Common Core Standards of K.CC.1: Counting and Cardinality, K.OA.1 and K.OA.2: Operations and Algebraic Thinking for her kindergarten-aged students. She was also able to differentiate her instruction for this lesson and incorporate the first-grade operations and algebraic thinking Common Core Standard (1.OA) and second-grade operations and algebraic thinking Common Core Standard (2.OA) for the older students in her class.

In planning for this activity, the teacher created a poster with 12 boxes. The numbers 4, 5, 6, 8, 9, and 10 were placed in various boxes on the poster (see Figure 3). The teacher had a small basket with several number sentences written on index cards in it. She also had a set of small blocks to be used as counting manipulatives. Each student was asked to pick a number sentence from the basket, read it, identify if it was addition or subtraction, and solve the problem. If the student answered correctly, either verbally or using the manipulatives, they then had to "program" the BeeBot so that the robot would stop on the answer to their number sentence. BeeBot was programmed to go forward, backward, turn left and right. The teacher asked the students to program one direction at a time until the BeeBot reached the desired number.

Figure 3. Math Activity with BeeBot

During the post-observation interview, Primary Teacher Allison stated that her main goal for the lesson was for the students to be able to read the symbol for addition or subtraction and be able to perform the correct operation. She stated that she was happy with the way the lesson turned out because her students were able to complete the task. She stated, "They did it, they followed, they were excited about it, they waited their turn, they listened, and they tried to help one another a little bit" (Primary Teacher Allison, post-interview, 11/15/2017). When asked if she saw a difference with the addition of robotics to this lesson, she explained that with the addition of robotics her students were more engaged, they stuck with it, and they were excited about learning. They wanted to use the robot. She definitely saw an increase in their level of motivation for the lesson when using the BeeBot then she saw in similar previous lessons without the robot.

When the researcher asked if the participant felt that the use of robotics increased engagement and goal achievement in her students, she responded "Definitely." She went on to state:

> I don't know what it is about the robots, whether it's the little beeping sounds, the movement, whatever it is about the robots, they really enjoy it, and they really want to see the robot move or make sounds. So they're really engaged in it. And it seems so basic and so simple, but for them it's a big thing. They saw the BeeBot, and they are already excited at the beginning. I don't have to pump them up or try to convince them that it is going to be fun. I can just show them, and they know as soon as they see BeeBot that they're going to have fun. (Primary Teacher Allison, post-interview, 11/15/2017)

Finally, she stated that some of the biggest factors and constraints that affect robotic implementation in her classroom are planning and time. “Our students get pulled in so many directions during the day with specials and therapy. When you have a lesson with robotics, you need to make sure that you plan ahead and have the time to see the lesson through” (Primary Teacher Allison, post-interview, 11/15/2017). She uses them because the students love them and they are more engaged by robots than any other piece of technology that she brings into her classroom.

High School Teacher Sarah: The next study participant is relatively new to A. Harry Moore School. High School Teacher Sarah has been teaching students with low-incidence disabilities for approximately four years at A. Harry Moore. She currently teaches students aged 14-16 on High School content standards. She was first introduced to robotics during student teaching where she used robotics during circle time activities with her Kindergarten class. Today, she tries to implement a variety of technologies, including robotics, into many of her lessons.

When asked about her thoughts and opinions on implementing robotics into her lessons she stated, “I absolutely love using robotics” (High School Teacher Sarah, pre-interview, 11/18/2017). She explained that they are a great “attention getter” for her students and using them for a variety of subject areas helps to keep her students engaged in the lesson for longer periods of time. Her educational and IEP objectives for robotics implementation stem from helping her students to not only grasp concepts more easily but to add a playful element to learning. She felt that even her students whose disabilities prevent them physically from participating in your typical paper and pencil activities have more of a level playing field when participating in an activity where they can control a robot to answer a question.

Participant High School Teacher Sarah also felt that the use of robotics in her lessons has contributed to an increase in her student's educational goal achievement. She stated:

> I feel like they're more motivated to try harder and they might get an answer quicker, or they might achieve the answer or understand the concept sooner than if I would have just explained it with paper and pencil or just use the internet to show them videos. I feel like anything hands on always helps the child to understand the concept or to retain knowledge in a more fun and engaging way. (High School Teacher Sarah, pre-interview, 11/18/2017)

Additionally, she feels that her students are also interested in how the robotics work and enjoy the additional benefit of learning how to code the robot along with achieving the goal of the lesson.

High School Teacher Sarah presented a geography lesson on the location of the different states on a map of the United States. She indicated that this lesson addressed U.S History: America in the World content standard 6.1.4.B.6. For this lesson, her objective was to have the students identify the various states on a map. The teacher stated that the students had been studying the location of the states on a map for a few weeks using paper maps, YouTube videos, bingo games, or pointing them out on the Promethean Board.

> Using robotics is a great way to engage children in the lesson and even our lowest functioning students because they can look and participate and maybe

control the robot using their iPad where they might have a difficult time holding a pencil to show that they understand the lesson. (High School Teacher Sarah, pre-interview, 11/18/2017)

For this activity, High School Teacher Sarah used a large map that was placed on the floor in the school's auditorium. She stated that in preparation for the lesson, she reserved the Dash robot from the Technology Coordinator a few days in advance to make sure that the robot was ready and charged. All students formed a circle around the map. The teacher explained that the students were going to use an iPad to drive Dash to the state that she called out (See Figure 4). Each student was given a turn to control the robot with the iPad and find the state indicated by the teacher. After each student had two turns with the states, she asked the students to drive the robot to the various coasts (north, south, east or west) to give them practice with directionality and symbols found in a map legend. Finally, she differentiated instruction for some of the higher functioning students by asking them to locate a state based on its capital or state bird.

Figure 4. Geography Activity with Dash

During the post-observation interview, High School Teacher Sarah indicated that this activity was a continuum of a whole unit on the states of the United States they had been working on for a few weeks. She felt that the lesson went as planned and that the students were successful in identifying the states either on their own or with assistance from their peers or the teacher. She felt that everyone was engaged and excited by the lesson. When asked what she would change about the lesson the next time she presented it, she stated that she would allow for more time and possible use two robots so that two students could race to see who could get to the state first. She also felt that the students were more successful finding the states on the large map with the robot then they had been when using paper and pencil in the classroom.

When asked if the participant found value in the use of robotics with her students she excited stated: "Yes, because I think they're engaged, it [robotics] gets them on board and they are absolutely excited about learning and participating" (High School Teacher Sarah, post-interview, 11/21/2017). She also explained that they can't wait to have a turn or help their classmates and that they learn in a playful way. She knows that they are engaged in the lesson because they are actively participating and she appreciates the fact that she can quickly and easily gear a lesson down for lower functioning students or make a task for difficulty for higher functions students quickly and easily.

For the factors and constraints of robotic use, High School Teacher Sarah explained that time is one of the factors that influence robotic implementation in her classroom. "Sometimes it is not always practical really quickly to incorporate robotics into the everyday life of learning because the whole school shares them," she explained (High School Teacher Sarah, post-interview, 11/21/2017). Most teachers have to plan ahead and reserve the robots so using them "on the fly" is not really possible. She also explained that sometimes the robots have "a mind of their own" or sometimes the WiFi or Bluetooth goes out, and you have to quickly adapt your lesson while trying to reconnect the robot. Finally, she stated that "using electronics, in general, we are reaching their generation and what they are interested in doing so we are keeping them more engaged and maybe more excited about learning" (High School Teacher Sarah, post-interview, 11/21/2017).

Middle School Teacher Charlotte: Study participant Middle School Teacher Charlotte has been teaching students with low-incidence disabilities for 28 years with 24 of those years being at the A. Harry Moore School. She currently teaches students aged 9 – 12 who are completing goals on the 4th to 6th-grade level. She had been using robotics for the past three years as a way of engaging students in content that may be a higher level academically than their current functioning level she explained. "I've used it [robotics] as a way for students to participate in hands-on activities and to explore and expand on their current knowledge," states Middle School Teacher Charlotte during our pre-observation interview (Middle School Teacher Charlotte, pre-interview, 11/19/2017).

When asked about her thoughts, opinions and educational and IEP goals and objectives of robotic implementation within her lessons, she stated that robotics have been very useful in her classroom because they give her students a way to showcase what they know, they keep them engaged for longer periods of time, and they allow her students to demonstrate what they are learning. "I think for me, the objective of implementing the robotics is to help my students increase their current learning task and keep them engaged in lessons long enough for them to comprehend or demonstrate comprehension of the goal," she explained (Middle School Teacher Charlotte, pre-interview, 11/19/2017). She also feels that using robotics is a fun way of helping them to engage. Since implementing robotics, she feels that her students stay on task for longer periods of time which helps them to gain the information that she is working on and "has made positive roads towards them achieving their goals" (Middle School Teacher Charlotte, pre-interview, 11/19/2017).

The lesson that the researcher observed was a history lesson that reviewed the passage of the Mayflower from England to America as a part of a Thanksgiving activity. The core standard that the lesson addressed was 6.1.4.D.5: Key historical events, documents, and individuals led to the development of your nation. The educational goal of the activity was to have the students demonstrate an understanding of the passage that the pilgrims took from England to the new world and how it was a difficult and dangerous voyage. In preparation for the lesson, Middle School Teacher Charlotte re-created the Mayflower out of paper, created index cards that indicated locations along the journey and procured a sphero robot from the computer lab. At the beginning of the lesson, the teacher animatedly retold the story of the Mayflower and the Speedwell. As she told the story, she placed the index cards on the floor with the names of the places the Mayflower passed along the journey. She told of the trials and tribulations of the passenger and crew on this 66-day journey. After the retelling of the story, the teacher wanted to see if the students remembered the path and the story. She asked each student to drive the Sphero robot, which had been covered with the paper replica of the Mayflower (see Figure 5), along the path on the floor in the correct order. Before starting, the teacher used her body to model the route. If the student remembered the correct path, the teacher allowed the students to drive Sphero through a bucket of water to simulate the passing through the ocean.

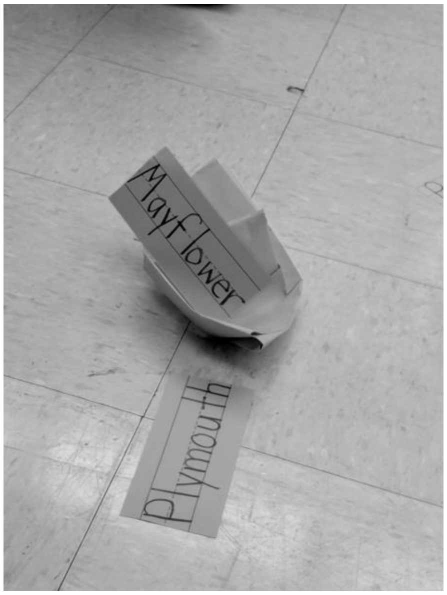

Figure 5. Mayflower Activity with Sphero

During her post-observation interview, Middle School Teacher Charlotte explained that she first planned for this lesson by reviewing her content standards, understanding what her actual goal was and then looking at how she could get the student to be interactive and stay engaged in the activity. "Using the robotics to give them that hands-on experience of recounting what we had already studied through video and text gave us another way to expand on the activity," she explained (Middle School Teacher Charlotte, post-interview, 11/22/2017). When asked if she thought the lesson went as planned, she said that nothing goes exactly as planned but she thought the students received the lesson well and that they were engaged. She thought that they were able to recount, with assistance, the concepts of who was involved, that it was the pilgrims and they were able to recount the passage of the individuals involved. She also felt that the students understood the reason why the pilgrims were leaving one area and going to another area, the length of the time it took to travel, and the hardships they faced along the way. When similar lessons were taught with only written text and visual aids, "it didn't give the students the actual feel of a hands-on experience and didn't allow them to really demonstrate what they understood" (Middle School Teacher Charlotte, post-interview, 11/22/2017).

When asked if Middle School Teacher Charlotte felt that the use of robotics within her lessons increased engagement and goal achievement she stated, "Yes, if the lesson is really tied to the use of robotics in a way that is meaningful" (Middle School Teacher Charlotte, post-interview, 11/22/2017). She also feels that robotics does increase goal achievement with her students but "you have to make sure that you are using it effectively as a tool within the lesson and not as a toy" (Middle School Teacher Charlotte, post-interview, 11/22/2017).

Middle School Teacher Charlotte also indicated that time to effectively implement the robotics and the student's physical ability are the biggest constraints to robotic use in a classroom. Do they have the fine motor skills or the gross motor skills to use the robotics appropriately? When asked about the factors that influence the use of robotics in her classroom she shared:

> Having the time, because when you apply the use of robotics in a lesson, it does increase the amount of time for the hands-on portion of your activity, the demonstration of the activity itself, and what do you expect students to do with it. And for them to actually get comfortable with the use. So that increases the amount of time you have to give for that particular lesson. And in a busy day sometimes you don't have the time to really implement the robotics the way it

> needs to be done. Secondly, it's students physical ability. Are students able to physically maneuver [the robot]? The fine motor skills or the gross motor skills necessary to manipulate the technology to use it appropriately. I don't see their cognitive abilities as being a positive or a negative because you build the lesson around where your students are so I try to make sure that the activity is geared to the needs of the students and the student's capabilities. (Middle School Teacher Charlotte, post-interview, 11/22/2017)

She also shared that the other thing she sees that causes the most influence is whether or not the technology is working. She feels that properly working technology is the biggest factor to whether it is a positive or a negative lesson.

Teacher Denise: The final teacher participant of this study is a teacher with 29 years of experience teaching students with low-incidence disabilities at the A. Harry Moore School. While she has taught all ages groups in the school, she specializes in engaging the students in physical and recreational activities. Typically when infusing technology into her lessons, she frequently uses the Wii and the X-Box with the Kinect sensor, but she is also familiar with Dash and Sphero.

When asked about her thoughts and opinions on robotics implementation, she stated that she felt they were very helpful because they give some of the limited students more of a level playing field.

> When I use the Wii, I feel the student with the remote is at the same level whether they are in a wheelchair or not, everyone with the remote is the same and it is the same with the robotics, they make the playing field very even. (Teacher Denise, pre-interview, 11/20/2017).

With goals that are mostly leisure and recreational in nature, she feels that goal achievement for her students is based mostly on repetition. "If I do it repetitively enough then yes, I will see results," she explains (Teacher Denise, pre-interview, 11/20/2017).

The activity that was observed by the researcher took place in the gym of the A. Harry Moore School. This space is specifically adapted for students with physical disabilities. It contains basketball hoops that are lower in height, a group of adaptive bicycles, a swing specifically designed to hold a wheelchair, and a soft play area with a ball pit. One the day of the observation, the teacher set-up three distinct bowling areas and borrowed both the Sphero and Dash robots from the computer lab. The first area was set as a "traditional" bowling alley. The space contained ten bowling pins at the end, and the students were given a lightweight rubber bowling ball to physically throw at the pins. Students who were unable to throw the ball used an adaptive bowling ramp to push the ball toward the pins. The second area contained a 4-foot table with six smaller sized bowling pins at the end of the table. The sides of the table had pool noodles attached to them. At the front of the table were an iPad and a Sphero robot (see Figure 6). The object at this station was to have the students use the iPad to drive Sphero to knock down the pins. This lane had the added advantage of having the bowling pins at eye-level for those students who had visual difficulty and could not look down at the pins on the floor. The third bowling area was similar to the first. This space resembled a "regular" bowling lane with the exception of the ball. Instead of a bowling ball, students needed to use an iPad to control Dash down the lane to knock down the pins (see Figure 7). All students were given an opportunity to bowl at all three stations.

Figure 6. Bowling Activity with Sphero

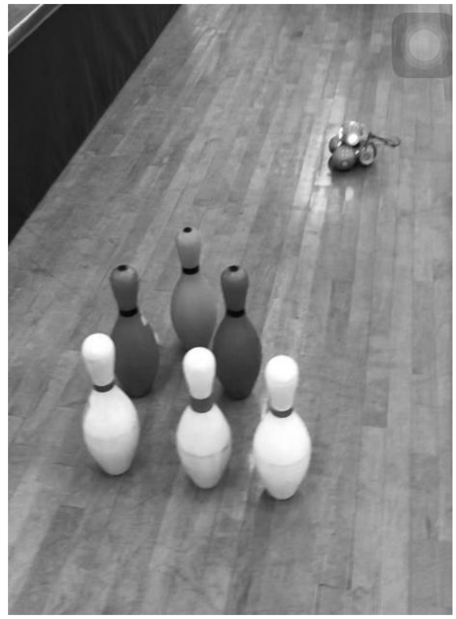

Figure 7. Bowling Activity with Dash

Participant Teacher Denise explained to me during our post-observation interview that her goal for this activity was not only to teach the students the rules and mechanics of bowling but to “throw in a little math lesson in there and have them count their pins and add up their score” (Teacher Denise, post-interview, 11/21/2017). Although she had done this lesson previously with many classes, she felt that the students did really well and was surprised that one of the students actually bowled better using Dash then physically throwing the ball himself. “With Dash, he could actually aim the robot at the pins and knock them down, but when he tried to physically throw the bowling ball at the pins, he continuously missed and subsequently got very frustrated,” she explained (Teacher Denise, post-interview, 11/21/2017).

When asked how Teacher Denise measured engagement and goal achievement with her students she replied:

> I measure it if they’re happy. That’s my goal, for them to be happy and for them to have fun. I can see if they are able to knock the pins down and if the are not

> able to knock the pins down then I will bring in another technique so that they're successful. So, this one student wasn't successful with the first choice I gave him, so I gave him Dash, and he was successful. So, that's basically how my class works, if you're not successful one way, then we will find a way for you to be successful and robotics works for that. (Teacher Denise, post-interview, 11/21/2017)

She also feels that the students were very engaged with the robotics. She explained that being in a technology-rich world, robotics brings a different aspect to the game. She thought it was challenging but could see how excited the students were when they could actually knock the pins down. "Especially the students with limited mobility, they have so much more control when they have Dash or Sphero doing the work for them," she explained (Teacher Denise, post-interview, 11/21/2017).

Therapeutic Participants

Occupational Therapist Andrea: Participant Occupational Therapist Andrea has been an Occupational Therapist at the A. Harry Moore School for 26 years. She has been providing therapeutic services for students with low-incidence disabilities throughout her career. When asked about her background in implementing robotics into her therapy sessions she stated that after robotics was introduced to the school, she began to bring students down to the technology lab as an "alternative activity to what would normally be considered pull out therapy in the therapy room" (Occupational Therapist Andrea, pre-interview, 11/29/2017). She said robotics was seen as another thing in her "toolbox" that could get the kids excited about their therapy and "kind of trick them into doing a lot more work" (Occupational Therapist Andrea, pre-interview, 11/29/2017).

When asked about her thoughts and opinions on robotic implementation into her therapy sessions she explained that she thought it was exciting and that kids today are geared toward our modern tech-oriented world. "Occupational Therapy, the sort of old-time fine motor skills of beading and basket weaving, is not interesting to them so robotics and technology I think gives them a way to get excited about something that might normally be a more mainstream activity," Occupational Therapist Andrea explained (Occupational Therapist Andrea, pre-interview, 11/29/2017). While she considers herself more of a manual therapist, she did describe one group session where a class was using a BeeBot, and she was surprised how excited the students were to use the robots and "how they started to get the concept of laterality, directionality, and sequencing" (Occupational Therapist Andrea, pre-interview, 11/29/2017). After that experience, she said she knew she had to start using them more often in her therapy sessions.

Participant Occupational Therapist Andrea also stated that she does see an increase in therapeutic goal achievement with the introduction of robotics. She explained:

> Things like directionality, left or right, there's only so many things you can do to keep a kid engaged about this is your left hand, and we're going to turn left. Whereas when we did the activity with the BeeBot, they were able to make it a two-step process and we had to turn the BeeBot left, and it would go two spaces, so then we could get BeeBot to what the goal was. And I think they actually got better at sequencing because then the next time we did the activity they were able

> to sequence much faster and they had a lot less wrong choices. (Occupational Therapist Andrea, pre-interview, 11/29/2017)

For Occupational Therapist Andrea's observation, she chose to incorporate robotics into a handwriting program called Handwriting Without Tears™. She explained that Handwriting Without Tears™ is a developmental handwriting program that uses multimodal tools to try to teach letter formation such as Play-Doh™ or chalk and a chalkboard. She explained that the Core Curriculum Content Standard and IEP goal that this activity addresses is 2.5: All students will learn and apply movement concepts and skills that foster participation in physical activities throughout life and all students will demonstrate self-management skills.

For this activity, which took place at the table in the computer lab, she used an Ozobot as one of the tools for teaching letter formation. To prepare for the lesson, Occupational Therapist Andrea collected the required materials and utilized one of the Ozobots already housed in the computer lab. After settling the student in his chair, the therapist drew the letter "L" on a piece of paper and asked the student to name the letter. After the student named the letter, she placed the Ozobot at the top of the letter and had the student watch as the robot traced the letter (see Figure 8). The therapist then asked the student to draw the letter "L" and told him that if he completed the letter correctly, he would be able to use the robot to trace the letter. The therapist encouraged the student to use his pincer grasp to pick up the robot and his pointer finger to turn on the robot. After successfully completing the letter "L," they went on to complete the letter "H" and the number "7." At the culmination of the activity, the student was asked to write his name and then place the robot on each letter.

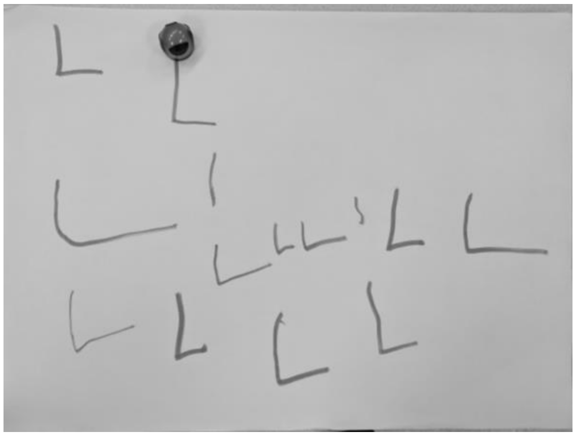

Figure 8. Handwriting Activity with Ozobot

At her post-observation interview, Occupational Therapist Andrea explained that her therapeutic goal for this activity was to see if the student remembered any of the rules for Handwriting Without Tears™, to have appropriate fine motor skills during handwriting, and to make a noticeable and recognizable letter and/or number. She felt like the activity went mostly as planned but when they got to the letter "H," she realized that the robot was not going to follow the rules from Handwriting Without Tears™ and had to explain that the robot was not able to "jump to the middle" like he was supposed to do. She said that he got very excited that the robot wrote a letter like he did, especially when it was his name. She felt that he was much more engaged with the robot than he had been in previous sessions where handwriting had been the focus. She explained:

> Usually with just the regular Handwriting Without Tears™, once he's written it, he's done with it. He doesn't want to re-go over it or talk about the rules anymore, but the robot kind of made it so that he was now going to do it again which he normally will not do. (Occupational Therapist Andrea, post-interview, 11/30/2017)

She said that she would definitely do the activity again but would make sure she concentrated on letters that the robot would be able to complete using the Handwriting Without Tears™ rules.

When asked if Occupational Therapist Andrea felt that the use of robotics during her therapy sessions increases engagement and goal achievement, she stated:

> I do because the more they are engaged, the more likely they're going to do it often. And kids with low-incidence really need to do things repetitively to actually own them. And for some of the things that they struggle with, it's really hard for them to be excited about doing the same thing over and over again. Whereas the robotics was a way that they could practice it in a way that was exciting. So I think that their goals will be achieved a lot faster because I won't have to struggle with them doing the repetition part of learning a skill. (Occupational Therapist Andrea, post-interview, 11/30/2017)

Finally, Occupational Therapist Andrea felt that some of the factors and constraints of robotics implementation she experiences involve the budgetary constraints and time and planning. She feels that you need to have enough of the robotics for multiple classes and therapists to use them at the same time. She feels that many people get frustrated when they want to use the robots and they are not available at the time. She also feels that robotics, or any technology, "loses its play value" during therapy if it is broken or not working properly. She feels that it is also very important to plan ahead for activities that involve robotics. "I have to remember to plan ahead to get a robot or to plan a session around the robot and then making sure all of the pieces fit together," she explained (Occupational Therapist Andrea, post-interview, 11/30/2017).

Speech Therapist Olivia: Participant Speech Therapist Olivia is a Speech-Language Pathologist who has been working at the A. Harry Moore School providing therapeutic services to students with low-incidence disabilities for nine years. Before consenting to participate in this study, she had not attempted to implement robotics into any of her therapy sessions. She frequently uses an iPad with various speech-related applications and thought that the actions and movements of the robots would help her students "to visualize what is right there in front of them" (Speech Therapist Olivia, pre-interview, 11/30/2017). "Think I will see more improvements when I use the robotics because the robotics are a motivation by themselves, so it will help the kids talk more about it," she explained (Speech Therapist Olivia, pre-interview, 11/30/2017).

For her observation, Speech Therapist Olivia chose a sequencing activity for her two students aged nine and ten. Prior to her session, she had the Technology Coordinator give her a refresher course on how the Ozobots operate and then borrowed them for the session. During her pre-observation interview, Speech Therapist Olivia indicated that the Core Curriculum Content Standard she would be addressing in her session would be 3.3: All students will speak in clear, concise, organized language that varies in content and form for different audiences and purposes.

At the beginning of the session, the two students sat at a small table in the therapist's office, and the therapist presented them with a set of three cards, a piece of paper and a marker. The goal of the activity was to have the students place the cards in the correct order so that they told a complete story. She had the students take turns placing their three cards at the top of their piece of paper. The therapist then asked the students to draw a line from the bottom of the paper to each one of the pictures. Finally, she asked them to place the Ozobot on the line that pointed to the first picture in the sequence (see Figure 9). When the robot reached the picture, the student was asked to describe what was happening in the picture. Each student completed two sets of pictures during the 30-minute session.

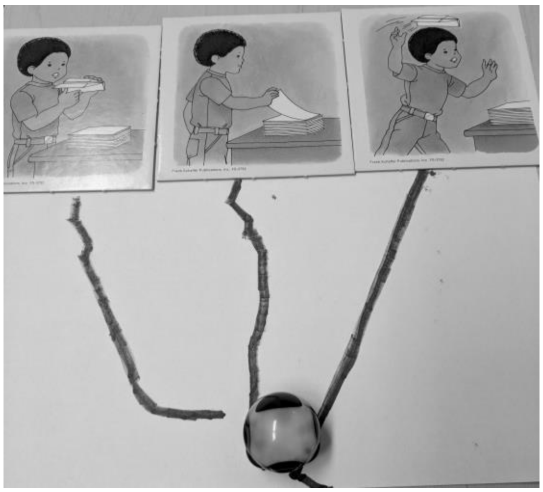

Figure 9. Sequencing Activity with Ozobot

During her post-observation interview, the researcher asked Speech Therapist Olivia about her therapeutic goals for the lesson and if she thought the lesson went as planned and was well received by her students. The participant explained that her therapeutic goal for the lesson was for the students to sequence the pictures in the correct order and describe the scene as depicted. She wanted them to work on their expressive language skills. She explained that she felt that one of the students did very well, followed directions and was motivated by the robotics. She also stated, “I don’t think [the other student] was motivated by the robot but it gave me an insight like perhaps I have to break down the lesson, or what I can do to make it fun next time” (Speech Therapist Olivia, post-interview, 11/30/2017). She also felt that the incorporation of having to draw the lines and use the robot limited the number of sequencing tasks they were able to complete but felt that the students were more interested in the lesson with the addition of the robotics then they had been on previous occasions when this same lesson was presented without the use of robotics. When asked if she found value in the use of robotics during speech therapy she stated:

> I think there was a clear value in using robotics. Especially nowadays, technology in general just grasps the attention of children more. So incorporating a simpler version of technology, such as a gliding robot across the table, was motivational. Since the robot was able to change colors, we can incorporate a little bit of different questioning such as differentiating colors. (Speech Therapist Olivia, post-interview, 11/30/2017)

She also explained that while both of the students were interested in the robots, the session might have been more productive for the second student in an individual session and not in a group session.

Finally, Speech Therapist Olivia felt that one of the biggest constraints or factors that influence robotic implementation in her therapy session would be more time for planning. She felt that as a speech therapist she had to spend too much time on the mechanics of drawing lines. She felt that if she had pre-drawn lines printed out on paper that the students could move, then she would have more time to work on her goals.

Physical Therapist Elizabeth: The final participant to discuss the therapeutic aspect of robotic implementation at the A. Harry Moore School is a Physical Therapist with 11 years of experience providing therapeutic services to students with low-incidence disabilities. She has been working at A. Harry Moore for the past four years and was first interested in robotics when she participated in an art activity where students used a

Sphero robot, dipped in paint, to create unique works of art. What impressed her most was the fact that even the students with limited mobility and use of their hands were able to participate in the art project.

Participant Physical Therapist Elizabeth believes that robotics are a great way to motivate kids who are in wheelchairs to self-propel or kids who are learning to ambulate to walk more steps. She explained that her number one therapeutic objective for implementing robotics would be "getting kids who have limited physical abilities, because of their diagnoses, to really participate and be motivated about movement" (Physical Therapist Elizabeth, pre-interview, 12/6/2017). She went on to say:

> Personally, I think outside of this environment, they're not getting a lot of movement. I think they go home and they stay home. So when they're here, and of course it's supposed to be an academic environment also, but I think any opportunity I can get to work something [robots] that's motivational, I take it. So I think it's not only therapeutic, but it's also multifaceted within a school environment. (Physical Therapist Elizabeth, pre-interview, 12/6/2017)

She stated that she is continually impressed by the creativity of the teachers when they incorporate technology and robotics into their lessons. "It is amazing how technology, something as simple as a Fitbit™, can motivate a student who usually never gets out of his wheelchair, to want to walk around the school and "get his steps in" (Physical Therapist Elizabeth, pre-interview, 12/6/2017).

For her observational activity, Physical Therapist Elizabeth chose to set-up an obstacle course in the school auditorium. She procured all necessary equipment for the activity and borrowed a Dash robot from the computer lab. For this session, Physical

Therapist Elizabeth explained that she would be addressing Core Curriculum Content Standard 2.1: All students will learn and apply movement concepts and skills that foster participation in physical activities throughout life. The student she was working with was 18 years old and a fairly new power wheelchair operator. The therapist explained that she was continually driving into chairs and desks and doors. Her goal was to have the student drive through a series of cones without hitting any of them. When trying this activity previously, the therapist would ask the student to follow her through the cones but found that she had a hard time instructing the student while walking backward through the cones. She also felt that the student disliked this activity and wasn't motivated to pay attention to where the cones were located. This time, the therapist asked the student to follow Dash through the series of cones (see Figure 10). The therapist stood behind the student and controlled Dash with the iPad. The student was instructed to follow Dash but be aware of the cones and try not to hit any of them. Each of the trials was timed, and the therapist recorded the number of cones that the student hit. By the end of the third trial, the student was able to successfully navigate through all of the cones without hitting any of them.

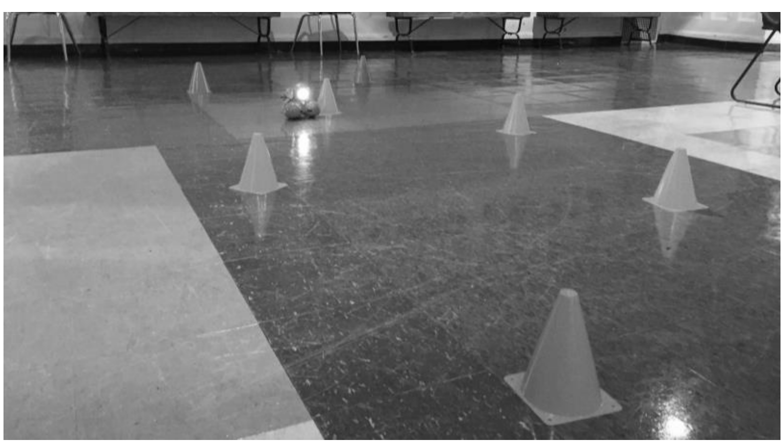

Figure 10. Power Wheelchair Training with Dash

During the post-observation interview, Physical Therapist Elizabeth explained that her therapeutic goal for the session was for the student to recognize obstacles and avoid them. She felt that using a robot instead of her own body, as she had done in previous sessions, was beneficial because "a robot is a small target, and she'd have to pay more attention to the robot, and she could actually see where it was going without prompting" (Physical Therapist Elizabeth, post-interview, 12/11/2017). When asked if she thought the lesson went as planned she replied:

> Yeah, I think it went better than I planned it because I think it was a lot of fun and she did one practical trial and three other runs, and she didn't complain. Normally we do it one or two times, and she starts complaining because I think she gets bored with doing it and with me giving her a lot of prompting. With this, she just followed the robot in the direction that the robot was traveling through the course. (Physical Therapist Elizabeth, post-interview, 12/11/2017)

She felt that the next time she practiced this activity with the student, she would be a little more rigid about the distance traveled so that she could quantify it. She also thought that she could have the robot proceed two or three steps ahead of the student and see if the student could remember all of the steps. When asked if she found value in the use of robotics during therapy she replied:

> I absolutely found value in it. I would like to apply it to some real life situations like create obstacle courses around chairs or wheelchairs and garbage cans, things that she would face on a daily basis especially within the school. I didn't give her credit for her abilities before. I didn't think she was going to be that good with a

> robot and be able to follow a robot that was making several moves. (Physical Therapist Elizabeth, post-interview, 12/11/2017)

In the future, she wants to see how she can incorporate the robots when training the student to drive in reverse.

Among the constraints and factors that influence robotics use during therapeutic sessions, Physical Therapist Elizabeth mentioned availability and training. She acknowledges that there are only a few robots available to the whole school and being diligent and planning ahead for their use is an important factor. She also feels that more training is needed for successful implementation. “Working on this project made me think about how easy it is to use technology, how the kids really enjoy it, and how it can be part of my therapy sessions,” she explained (Physical Therapist Elizabeth, post-interview, 12/11/2017).

Data Analysis Method

The researcher used Yin’s (2013) five-phased cycle for coding case study data. The coding process included: (a) compiling; (b) disassembling; (c) reassembling; (d) interpreting; (e) concluding. The compiling phase was the process of transcribing the recorded interviews and handwritten observation notes verbatim into Word documents and then importing those documents into NVivo 11 software for analysis. Also included in the first phase, the researcher read and re-read the texts from interviews and observation notes. After familiarization, the researcher performed disassembling, which involved breaking down the data into smaller codable words, phrases, and sentences that were relevant to the research questions of the study. The researcher then assigned new labels or codes to each of the relevant fragments or pieces of information from the transcripts and observation notes. In NVivo, the first phase involved creating nodes and labeling them with descriptive phrases that were indicative of the meaning of the data as the data related to the research questions. Data elements (e.g., words, phrases, or sentences) were then coded under the applicable nodes. In the third phase, the researcher clustered similar codes into relevant groups to form themes (Yin, 2013). In NVivo, the third phase involved creating parent nodes that were labeled with descriptive phrases indicative of the content of similar codes and then reclassifying the codes as child nodes under the applicable parent nodes. In the fourth phase, the researcher used the grouped data to develop a narrative of the overall interpretation of the data. In the fifth phase, the researcher developed conclusions and presented recommendations based on the findings (Yin, 2013). The presentation of findings below indicates the codes that emerged during data analysis and the number and percentage of participants who contributed to each code. Table 3 indicates the themes that emerged during data analysis and the number (i.e., frequency) and percentage of participants who contributed to each theme.

Findings

This presentation of the findings of the study is organized by research question. Findings associated with research question 1 indicated what role administration played in successful school-wide robotics implementation. In relation to research question 2, findings indicated how teachers' and therapists' knowledge and implementation of robotics impacted the educational and therapeutic IEP goals for students with low-incidence disabilities (LIDs). Findings related to research question 3 indicated what patterns emerged in the experiences and perceptions of teachers, therapists, and administrators during the implementation of robotics as an educational and therapeutic

Table 3

Themes an Theme Frequencies

Theme	Number of participants who contributed to theme
Major theme 1: Administrators' role involved managing resources to make robotics available, supporting teachers' and therapists' use of robotics by providing training and answering questions, and facilitating innovation in the use of robotics in education	2/2 administrators 3/3 therapists 3/6 teachers
Major theme 2: Teachers' knowledge and implementation of robotics impacted educational and therapeutic goals by enhancing student engagement and comprehension	6/6 teachers
Major theme 3: Therapists' knowledge and implementation of robotics impacted educational and therapeutic goals by enhancing student motivation and goal attainment	3/3 therapists
Major theme 4: Teachers, therapists, and administrators experienced time and funding as constraints during the implementation of robotics	2/2 administrators 2/3 therapists 4/6 teachers
Major theme 5: Administrators, therapists, and teachers perceived enhanced student achievement and engagement, and teachers experienced excitement, during the implementation of robotics	2/2 administrators 3/3 therapists 6/6 teachers
Major theme 6: The UDL principles of engagement, representation, and expression were represented by the implementation of robotics	3/3 therapists 6/6 teachers

tool for students with LIDs. In relation to research question 4, findings indicated what principles of Universal Design for Learning (UDL) are represented by the implementation of robotics into curricular activities for students with LIDs in their classrooms.

Research Question 1

Research question 1 was: What role does administration play in successful school-wide robotics implementation? The following theme emerged during data analysis to answer research question 1:

Major theme 1: Administrators' role involved managing resources to make robotics available, supporting teachers' and therapists' use of robotics by providing training and answering questions, and facilitating innovation in the use of robotics in education. Two administrators, three therapists, and three classroom teachers contributed to this theme. Table 4 indicates the codes that contributed to this theme, the number of participants who contributed to each code, and the percentage of participants who contributed to each code. The presentation of results related to research question 1 is organized by participant type.

Administrators. Two out of two administrators indicated that administrators' role in successful school-wide robotics implementation involved facilitating innovation and experimentation by helping teachers and therapists integrate robotics in new ways. Administrators reported that they facilitated experimentation by making robotics available to teachers and students and allowing those stakeholders to discover whether the technology-enhanced education. Administrator Ken described the philosophy behind this practice as follows:

Table 4

Major Theme 1 Codes and Frequencies

Code	Number of participants who contributed data to code
Administrators facilitate innovation and experimentation by helping teachers and therapists integrate robotics in new ways	2/2 administrators 2/3 therapists 2/6 teachers
Administrators facilitate training and answer questions about robotics	2/2 administrators 2/3 therapists 2/6 teachers
Administrators manage resources by budgeting and obtaining grants	2/2 administrators 2/3 therapists

> The first thing you can do is let it happen. Perhaps because we're a Laboratory School, the concept of being a laboratory school, you can use technology, and you can fail, it might not be as exciting as you thought. So, I think just letting it happen and allowing people to use it and experiment with it becomes important. (Administrator Ken, interview, 12/1/2017)

Administrator Kimberly emphasized the importance of allowing teachers, therapists, and students to experiment with new technology:

> If we could buy the robot and then put it in the hands of the kids, the therapists, the teachers, and say: What can we do with that? How can this impact physical therapy? How can we use this in art and how can we use this in social studies class? So, at A. Harry Moore, I felt like we had the freedom to buy the tech and put it in kids' hands and experiment with it. (Administrator Kimberly, interview, 11/8/2017)

Administrator Ken indicated that giving teachers the freedom to innovate and to spread their innovations was an important part of an administrator's role:

> Our philosophy is much like a college teacher if you will. Where teachers are free to innovate within their classroom. Each teacher will go out and use technology that they feel comfortable with until it reaches a point where more and more people are using it so that it becomes more widely held. Like SeeSaw was a good example where more people were using it so now seemingly everyone uses it. (Administrator Ken, interview, 12/1/2017)

Two out of two administrators indicated that administrators' role in successful school-wide robotics implementation involved facilitating training and answering questions about robotics. Facilitating training was closely related to facilitating innovation, according to Administrator Ken, who reported that teachers who had experimented successfully with new robotics technology were encouraged not only to set an example for other instructors but to train other teachers as well:

> The type of training is more turnkey training where teachers used it and then will train others to use it. I think since we probably don't have enough robots necessarily to go around to all the hundred students that's not a problem, we want them used. So those teachers that are interested in using the technology will use it. And I think it does build up to a point where hopefully if people see everyone using it, they will use it as well. (Administrator Ken, interview, 12/1/2017)

Administrator Kimberly spoke of recruiting teachers to train other teachers:

> When I was doing the third-round observations in March and April when I saw things that I liked, which was almost always, I said to the teachers you know

> would you model this in our next professional development. So then instead of me as the new supervisor standing up and saying this is what you need to do I would have an elementary teacher or middle school teacher do a 20-minute demo lesson of what they did in their observation. (Administrator Kimberly, interview, 11/8/2017)

Two out of two administrators indicated that administrators' role in successful school-wide robotics implementation involved managing resources by budgeting and obtaining grants. Administrator Kimberly described the procedure for purchasing robotics resources at prices below a certain limit:

> A. Harry Moore was nice because if the item was below a certain amount of money, we didn't have to say quote-unquote send it across the street. I forget what that amount was. I think maybe $5000 or $1500 hundred dollars. So that was nice because we could purchase things like Ozobots, Spheros things like that and it would just be a conversation between [administrators] without having to get people involved that don't necessarily understand the technology. (Administrator Kimberly, interview, 11/8/2017)

Administrator Ken described some of the considerations administrators considered when contemplating a financial expenditure:

> With technology, some of the things I consider is number one: is this a flash in the pan type thing. You know you're going to buy something that's not going to be used two or three years later. How much is it going to be used? And what difference is going to make? (Administrator Ken, interview, 12/1/2017)

Administrator Kimberly recounted the process of obtaining robotics resources for the school through a grant:

> I had the opportunity to apply for a grant through the Apple distinguished educator program that was going to give 10 Spheros to 10 different ADEs. So, I knew that Spheros had been great in the in the classroom and the high school classroom in Monroe. So, I thought it would be a good opportunity to bring this technology to a new school. And so, I applied for the grant. I got the grant. (Administrator Kimberly, interview, 11/8/2017)

***Therapists*.** Two out of three therapists indicated that administrators' role in successful school-wide robotics implementation involved facilitating innovation and experimentation by helping teachers and therapists integrate robotics in new ways. Occupational Therapist Andrea described how an administrator's facilitation of experimentation in a classroom had introduced a new therapeutic tool:

> When the technology coordinator started bringing robots into the tech lab, we started bringing kids down here as an alternative activity to what would normally be considered pull out therapy in the therapy room. And it was seen as a way to kind of have another thing in our toolbox that could get the kids excited about their therapy and kind of trick them into doing a lot more work. (Occupational Therapist Andrea, pre-interview, 11/29/2017)

Two out of three therapists indicated that administrators' role in successful school-wide robotics implementation involved facilitating training and answering questions about robotics. Speech Therapist Olivia stated, "I think I receive enough [administrative] support for successful implementation. When I try [robotics] out, that is when I see if I need more support or not" (Speech Therapist Olivia, pre-interview, 11/30/2017). Physical Therapist Elizabeth stated, "I have to say that people who are here, like the Technology Coordinator, I always feel that I could go to her if I have a question regarding technology" (Physical Therapist Elizabeth, pre-interview, 12/6/2017).

Two out of three therapists indicated that administrators' role in successful school-wide robotics implementation involved managing resources by budgeting and obtaining grants. Occupational Therapist Andrea suggested that administrators might perform this role more effectively than they were at present, by taking wear and tear into account:

> I think we get support if we ask for it. I think the equipment is very expensive and it being low-incidence, the kids are kind of rough on the devices. So, I think a lot of the times, based on the technology or the Wi-Fi, or them being rough with it, it's a lot harder than it is. So, I think it would be better if the support came from the Administration and providing new and updated sort of technology and robotics. (Occupational Therapist Andrea, pre-interview, 11/29/2017)

Physical Therapist Elizabeth described an instance in which a requested item was readily provided, perhaps as a result of the item's low cost, and indicated that more expensive resources might require a more arduous approval process before funding could be allocated:

> I asked for and received a Fitbit for one of my students. That's a low-cost item; I'm not sure if I asked for a more expensive technology item. I guess if I justified it, but funding is always a problem when you work in a public school. (Physical Therapist Elizabeth, pre-interview, 12/6/2017)

Teachers. Two out of six classroom teachers indicated that administrators' role in successful school-wide robotics implementation involved facilitating innovation and experimentation by helping teachers integrate robotics in new ways. Teacher Natalie described the support for innovation and experimentation from administrators at the school:

> I think our technology coordinator is aware of new technologies that might benefit our particular type of student. And I think that the school is open to the suggestions of the faculty and staff when we happen to come upon something that we might have seen online or might have seen at a conference. I think we have an atmosphere that's comfortable that you can bring that to the technology coordinator with you know a valid reason why you think that this is something that would benefit our students and that's always looked at and considered, and everyone's opinion is counted. So, I think it is a very supportive technology situation right now. (Teacher Natalie, pre-interview, 11/13/2017)

High School Teacher Sarah indicated that administrators made robots available to teachers: "I wish I personally, as a teacher, had more time to implement robots. But if I do have questions or if I need robots or I want robots, I think yeah, I have absolutely a lot of support" (High School Teacher Sarah, pre-interview, 11/18/2017).

Two out of six classroom teachers indicated that administrators' role in successful school-wide robotics implementation involved facilitating training and answering questions about robotics. High School Teacher Sarah indicated that administrators were responsive to questions about robotics: "if I don't know anything about a robot I can just ask a question [of the technology coordinator] and I get like a quick tutorial, a quick answer” (High School Teacher Sarah, pre-interview, 11/18/2017). Middle School Teacher Charlotte indicated that providing training in the use of robotics was an administrative role, but that administrators in the school had too many responsibilities to perform this role optimally:

> The support we receive or the support I receive in the classroom has been adequate but would be great if I could have more hands-on demonstrations. I think it's hard because we only have the one person in the building who's available to do it [professional development] and she's doing demonstrations for not just one class but for 20 different classes. So, it's difficult to get her in and continuously working in a classroom situation, but I think what we have is great. (Middle School Teacher Charlotte, interview, 11/19/2017)

Research Question 2

Research question 2 was: How do teachers’ and therapists’ knowledge and implementation of robotics impact the educational and therapeutic IEP goals for students with LIDs? Two major themes emerged during data analysis to answer research question 2, including teachers’ knowledge and implementation of robotics impacted educational and therapeutic goals by enhancing student engagement and comprehension, and; Therapists’ knowledge and implementation of robotics impacted educational and therapeutic goals by enhancing student motivation and goal attainment.

Major theme 2: Teachers’ knowledge and implementation of robotics impacted educational and therapeutic goals by enhancing student engagement and comprehension. Table 5 indicates the codes that contributed to major theme 2, the number of participants who contributed to each code, and the percentage of participants who contributed to each code.

Table 5

Major Theme 2 Codes and Frequencies

Code	Number of participants who contributed data to code
Teachers' knowledge and implementation of robotics impacted educational and therapeutic goals by enhancing student comprehension	6/6 teachers
Teachers' knowledge and implementation of robotics impacted educational and therapeutic goals by enhancing student engagement	5/6 teachers

Six out of six classroom teachers indicated that their knowledge and implementation of robotics impacted IEP goals by enhancing student comprehension of the curriculum, and five out of six teachers reported that their knowledge and implementation of robotics impacted IEP goals by enhancing student engagement. Primary Teacher Allison (teacher) spoke of maximizing student engagement and comprehension while working toward a range of educational and therapeutic goals through the implementation of robotics:

> Robotics allows me to differentiate the lesson, but they are all still doing the same activity. My goals would be for them to maintain attention during the lesson, to follow directions during the lesson, to comprehend the questions that are asked during the lesson. It depends on the student, and what the activity is so if it's a

> math lesson obviously those goals, whether they're practicing addition facts then that would be it. As for behavioral, are they sitting, are they attending, are they listening, are they following directions. Or their social goals, are they taking turns, are they engaged basically in the lesson. (Primary Teacher Allison, pre-interview, 11/14/2017)

High School Teacher Sarah described the implementation of robotics as a means of enhancing both engagement and comprehension:

> I would use the robot for them to maybe understand the concepts better in a more playful learning sense...You can see that they can you know apply what they have learned in previous lessons with a robotic tool basically and just take it even further and challenge themselves...even our lowest functioning students because they can just look and participate...using robotics can absolutely engage [students], to keep them motivated, keep them in the moment, in the lesson, challenge them, and you know get them excited about learning, keep them excited about learning. (High School Teacher Sarah, pre-interview, 11/18/2017)

Middle School Teacher Charlotte also cited the goals of increasing student engagement and comprehension:

> I think for me, the objective of implementing the robotics is to help my students increase their current learning task, whatever that task maybe it's to keep them engaged in it long enough for them to comprehend or demonstrate comprehension of the goal and using robotics as a fun way of helping them engage. (Middle School Teacher Charlotte, pre-interview, 11/19/2017)

Preschool Teacher Emma expressed how robotics would be used to enhance student engagement and comprehension in a specific lesson:

> I'm using the Ozobots, and we're going to have pictures of students faces, and I'm going to help the students by using hand over hand to create a line for the Ozobots to follow to help the students to identify their own face (see Figure 1). (Preschool Teacher Emma, pre-interview, 11/7/2017)

Researcher observations indicated that the implementation of robotics in the lesson just described by Preschool Teacher Emma allowed the following educational and therapeutic goals to be pursued: “Work on fine motor skills, pincer grasp, hand-eye coordination, visual tracking, identification of self, encourages communication” (Observational notes, Preschool Teacher Emma’s classroom). In a post-observation interview, Preschool Teacher Emma indicated how these goals were impacted by the lesson: “the children use[d] their pointer to turn the Ozobot on so using fine motor skills and identify themselves in a picture. And then also for eye-hand coordination” (Preschool Teacher Emma, post-observation interview, 11/8/2017).

Teacher Natalie described a lesson plan in which robotics would be used to demonstrate one of the operations of the circulatory system, indicating that the lesson would be conducted by,

> ...using small robotics called Ozobot and we are expanding on the lessons of the circulatory system so students will be using the Ozobots to demonstrate how oxygenated blood moves from the heart throughout the body and then after the oxygen is depleted from the blood how it moves back to the heart to be pumped to

> the lungs and then they will be using the Ozobots to do that (see Figure 2). (Teacher Natalie, pre-interview, 11/13/2017)

Observational notes were taken by the researcher during the lesson just described indicated that the implementation of robotics allowed the following educational and therapeutic goals to be impacted: “Work on fine motor skills, pincer grasp, hand-eye coordination, visual tracking, identification of parts of the circulatory system, encourages communication” (Observational notes, Teacher Natalie’s classroom). Use of the Ozobot impacted these goals in part because, “Fine motor skills are needed to turn on Ozobot and place it on the line [representing the circulatory system in the diagram of a human body]” and “Lights on robot enhance [students’] engagement” (Observational notes, Teacher Natalie’s classroom). High School Teacher Sarah described a geography lesson plan that involved robotics:

> The subject is going to be geography...So, I wanted to maybe just do states, just for them to identify the East Coast, West Coast, Northern, Midwest states that kind of stuff. And I want to do it on the ground, and then we can use the big map and then maybe we could use either Dash or BB8, one of those robots I feel would be nice (see Figure 3). (High School Teacher Sarah, pre-interview, 11/18/2017)

Researcher observations indicated that during the lesson just described, “The map was placed in the middle of the school’s auditorium and the students were in a circle around the map” (Observational notes, High School Teacher Sarah’s classroom). Observational notes further indicated that the implementation of robotics allowed the following educational and therapeutic goals to be pursued: “State Identification, Directionality (left/right, north/south, east/west, up/down) Visual Tracking, Hand-eye Coordination, Color Identification (the states were different colors), Verbalization/Communication skills" (Observational notes, High School Teacher Sarah's classroom).

Major theme 3: Therapists' knowledge and implementation of robotics impacted educational and therapeutic goals by enhancing student motivation and goal attainment. Three out of three therapists indicated that their knowledge and implementation of robotics impacted educational and therapeutic goals by enhancing student motivation and goal attainment. Table 6 indicates the codes that contributed to major theme 3, the number of participants who contributed to each code, and the percentage of participants who contributed to each code.

Table 6

Major Theme 3 Codes and Frequencies

Code	Number of participants who contributed data to code
Therapists' knowledge and implementation of robotics impacted educational and therapeutic goals by enhancing student motivation	3/3 therapists
Therapists' knowledge and implementation of robotics impacted educational and therapeutic goals by enhancing goal attainment	3/3 therapists

Physical Therapist Elizabeth indicated that overarching goals for the implementation of robotics included enhancing academic achievement and motivating students: “Number one [goal of implementing robotics] would be motivating, getting kids who have limited physical abilities, because of their diagnoses, to really participate and be motivated about movement” (Physical Therapist Elizabeth, pre-interview, 12/6/2017). Physical Therapist Elizabeth described the use of one device as an example:

> Like the Fitbit, the student I gave it to this morning is going to have a personal responsibility for the Fitbit. He's going to make sure it's charged. He's going to make sure it's safe. He's going to make sure that he uses it every day and then his teacher is going to make sure that he records his steps. So, you turn that into math or charting. You could do something academic based on the data that he's collecting. So, I think it's not only therapeutic, but it's also multifaceted within a school environment. You can do it educationally. But primarily motivationally. I think it's great for these kids. And plus, they’re doing what other kids do. (Physical Therapist Elizabeth, pre-interview, 12/6/2017)

Occupational Therapist Andrea gave a further example of the use of robotics to enhance student motivation and goal attainment:

> With the BeeBot, yes, I did see much more goal attainment. Things like directionality, left or right, there's only so many things you can do to keep a kid engaged about, this is your left hand we're going to turn left. Whereas when we did the activity with the BeeBot, they were able to make it a two-step process and we had to turn the BeeBot left, and it would go two spaces, so then we could get BeeBot to what the goal was. So, I think they got much more excited about that

as opposed to doing like a normal activity. (Occupational Therapist Andrea, pre-interview, 11/29/2017)

Speech Therapist Olivia anticipated improvements in goal attainment and motivation with the implementation of robotics:

> I think I will see more improvements [in goal attainment] when I use robotics because the robotics are a motivation by themselves, so it will help the kids talk more about it...It definitely helps. When I use the iPad, the kids love it. They ask for it when they come into the room. (Speech Therapist Olivia, pre-interview, 11/30/2017)

Researcher observations indicated how robots were used to enhance student motivation and goal attainment in specific sessions. Physical Therapist Elizabeth created the following lesson, in which robotics were used to enhance motivation and achieve therapeutic goals:

> The therapist set up an obstacle course with cones [in the school auditorium] and asked the student to follow the robot through the obstacle course. The therapist controlled the robot with the iPad, and the student had to follow the path of the robot. The student had to try not to hit any of the cones. Each of the trials was timed, and the student was encouraged to beat their time at the beginning of each trial (see Figure 4). (Observational notes, session with Physical Therapist Elizabeth)

In the session just described, robotics allowed the therapist and student to pursue the following therapeutic goals: “To be able to drive a power wheelchair through an obstacle course without hitting cones. Directionality (in, out, through, in front, behind) Visual

Tracking, Following directions" (Observational notes, session with Physical Therapist Elizabeth).

Occupational Therapist Andrea used robotics to reinforce letter recognition and hand-eye coordination, and to enhance motivation, in a therapeutic session with a student:

> For this activity, the therapist used the Handwriting without Tears curriculum to practice/ reinforce the letter "L" with the student. First, the therapist drew the letter "L" and asked the student to name the letter. After the student named the letter, she placed the Ozobot at the top of the letter and had the student watch as the robot traced the letter. The therapist then asked the student to draw a letter "L" and told the student that if he completed the letter correctly, he would be able to use the robot to trace the letter (see Figure 8). (Observational notes, session with Occupational Therapist Andrea)

In addition to enhancing letter recognition, Occupational Therapist Andrea used robotics in the session just described to pursue the following therapeutic goals: "Visual Tracking, Hand-eye Coordination (placing robot on the line, at the beginning of the line), finger isolation, fine motor skills, pincer grasp, Verbalization/Communication skills, Following directions" (Observational notes, session with Occupational Therapist Andrea). Speech Therapist Olivia arranged an activity to help students maintain motivation and attain the following goals:

> Express correct sequencing or order of events, correct grasp of a pencil or pen. Directionality (up/down, top/bottom) Visual Tracking, Hand-eye Coordination (placing the robot on the line, at the beginning of the line), finger isolation, fine motor skills, pincer grasp, Verbalization/ Communication skills (can tell a

> familiar story from pictures), Following directions. (Observational notes, session with Speech Therapist Olivia)

Speech Therapist Olivia's session was designed to achieve these goals in the following manner:

> The therapist used sequencing cards to have the students retell a story in the correct order. Each student was given three cards in an incorrect order. The students were instructed by the therapist to draw a line to each of the pictures. Then the student had to place the robot on the line that led to the first picture in the sequence. When the robot reached the picture, the student was asked to describe what was happening in the picture (see Figure 9). (Observational notes, session with Speech Therapist Olivia)

Research Question 3

Research question 3 was: What patterns emerge in the experiences and perceptions of teachers, therapists, and administrators during the implementation of robotics as an educational and therapeutic tool for students with low-incidence disabilities? Two major themes emerged during data analysis to answer research question 3, including teachers, therapists, and administrators experienced time and funding as constraints during the implementation of robotics, and; Administrators, therapists, and teachers perceived enhanced student achievement and engagement, and teachers experienced excitement, during the implementation of robotics.

Major theme 4: Teachers, therapists, and administrators experienced time and funding as constraints during the implementation of robotics. Table 7 indicates the codes that contributed to major theme 4, the number of participants who contributed to each code, and the percentage of participants who contributed to each code.

Table 7

Major Theme 4 Codes and Frequencies

Code	Number of participants who contributed data to code
Time is experienced as a constraint during the implementation of robotics	2/2 administrators 2/3 therapists 4/6 teachers
Funding is experienced as a constraint during the implementation of robotics	1/2 administrator 2/3 therapists

Administrators. Two out of two administrators perceived and experienced time constraints during the implementation of robotics. Administrator Ken indicated that time was a significant constraint on providing the necessary professional development for teachers and therapists to implement robotics:

> When I came here, there were only three days of professional development in the schedule, and it's not easy, you just can't add a day, unfortunately...I wish there was more time, in general, to squeeze in the hour, but unfortunately, with all the mandated training, there isn't the time to do that. (Administrator Ken, interview, 12/1/2017)

Administrator Kimberly also experienced time as a constraint on professional development during the implementation of robotics:

> I would say the one obstacle is definitely time because sometimes in a larger organization the job that you have to do and the job that you want to do are two

> different things. So sometimes when you do what has to be done the innovation piece, and the professional development piece can sometimes fall to the wayside. (Administrator Kimberly, interview, 11/8/2017)

One out of two administrators (Administrator Ken) experienced the cost of robotics as a constraint during implementation: “I think there is a cost obstacle. I think if I asked everyone if they would each like a bunch of robots in their classroom I'm sure they each would say yes” (Administrator Ken, interview, 12/1/2017).

Therapists**.** Two out of three therapists experienced cost as a constraint during the implementation of robotics. Physical Therapist Elizabeth indicated that funding was the only constraint that had been experienced during robotics implementation:

> The only constraints I can see here in this environment is cost because technology is pretty expensive. I do use the iWatch with my kids and Fitbits with my kids in addition to Sphero, which is a way to motivate kids. Kids who are in wheelchairs to self-propel, to walk more steps, those that can. So, the more funding I get and the more training I get, I would just love to use it with my kids because I think it's great. (Physical Therapist Elizabeth, pre-interview, 12/6/2017)

Occupational Therapist Andrea also reported experiencing the cost of robotics as a constraint during implementation: “I think the constraints are money. I think you have to have enough of the robotics involved for them to do it” (Occupational Therapist Andrea, post-interview, 11/30/2017).

Two out of three therapists experienced time as a constraint during the implementation of robotics, because extra time was needed to plan the incorporation of robotics into sessions. Occupational Therapist Andrea spoke of the challenge of balancing the needs of a large number of students while trying to plan the use of new technology to meet those needs:

> You know the constraints of having to do so many kids and so many other things in low-incidence disabilities, that it's sometimes hard to remember "oh this particular activity works really well", I have to remember to plan ahead to go get a robot or to plan a session around robots and then making sure all those pieces fit together. (Occupational Therapist Andrea, post-interview, 11/30/2017)

Speech Therapist Olivia also spoke of needing to take more time to plan the implementation of robotics: “I think it would just take a little bit more planning, but I feel like robotics could be involved with every type of therapy. It was just the planning part and innovation and creativity” (Speech Therapist Olivia, post-interview, 11/30/2017).

Teachers. Four out of six teachers experienced time as a constraint during the implementation of robotics. For Preschool Teacher Emma, the specific time constraint was related to the need to provide sufficient training to her staff without taking time away from student instruction: “I think if more time is spent training staff they would at least understand how to do it and it would take less time away from the lesson” (Preschool Teacher Emma, post-interview, 11/8/2017). Teacher Natalie reported that time was a constraint on the implementation of robotics in the classroom:

> For someone who sees students only for a certain period of time each week, time is an issue. I see technology and robotics as something that enhances my program, so I want to include it. But everything is based on time, and since I only have students for 30 minutes to an hour, I have to make sure I can fit everything

in there. So that is a problem. Obviously, you know, sometimes it just doesn't fit. (Teacher Natalie, post-interview, 11/14/2017)

Primary Teacher Allison stated that the primary constraint experienced during implementation of robotics was:

> The time, the planning, just mostly the time...the time that it takes to get it all together and to go through. So, it's more time consuming than you would think, and because it's technology it's supposed to go a little more smoothly but sometimes it doesn't, it takes longer. (Primary Teacher Allison, post-interview, 11/15/2017)

Middle School Teacher Charlotte also experienced time as the predominant constraint during the implementation of robotics:

> The biggest constraint is time. Having the time because when you apply the use of robotics in a lesson, it does increase the amount of time for the hands-on portion of your activity, for the training of how they are to be used, the demonstration of the activity itself, and what you expect students to do with it. And then for them to actually get comfortable with the use. So that increases the amount of time you have to give for that particular lesson. And in a busy day sometimes you don't have the time to really implement it the way it needs to be done. So, time is I think the largest constraint for me. (Middle School Teacher Charlotte, post-interview, 11/22/2017)

Major theme 5: Administrators, therapists, and teachers perceived enhanced student achievement and engagement, and teachers experienced excitement, during the implementation of robotics. Table 8 indicates the codes that contributed to major theme 5, the number of participants who contributed to each code, and the percentage of participants who contributed to each code.

Table 8

Major Theme 5 Codes and Frequencies

Code	Number of participants who contributed data to code
Perceptions of enhanced student engagement and achievement	1/2 administrator 3/3 therapists 6/6 teachers
Perception or experience of teacher excitement	1/2 administrator 5/6 teachers

Administrators. One out of two administrators perceived increased student achievement during the implementation of robotics. Administrator Ken indicated that robotics allowed students to perform actions they would otherwise be unable to accomplish:

> I think robotics takes an additional importance because of the movement. Where our children cannot move, robotics allows them to move. So, I've seen Sphero running to number two or running to number three or someone did something over the years with planets. Again, that's not something our children can easily do. So that manipulation of the environment, that doing things that they often can't do goes a long way...I think the difference with regular kids who use technology to do things faster quicker, with our kids they use technology to do things that they literally can't do. (Administrator Ken, interview, 12/1/2017)

One out of two administrators had perceived teachers' excitement during the implementation of robotics:

> The teachers were so excited about having a more hands-on way to teach their content area. I think I had like four or five Sphero that I had gotten from the company and they liked them so much that they started fighting over them. But that's a good thing to have teachers competing for resources because it shows that they're valuable. (Administrator Kimberly, interview, 11/8/2017)

Therapists. Three out of three therapists perceived increased student engagement and achievement during the implementation of robotics. Physical Therapist Elizabeth spoke of students with low-incidence disabilities using robots to accomplish tasks that children without low-incidence disabilities took for granted:

> It's great for kids who are very limited in their mobility to be able to use maybe the tablet to control the robot, and they're doing what other kids do you know. It is different than physical therapy, but I think it's great for kids to feel normal like they can do what other kids do which is great. (Physical Therapist Elizabeth, post-interview, 12/11/2017)

Physical Therapist Elizabeth also indicated that robotics enhanced student achievement by allowing students to be creative:

> I've seen some of the kids use the Sphero to do artwork and I think that's really fascinating too. I think it's an opportunity to be creative. And I think the kids are the beneficiaries of it because again they enjoy technology and it's what regular kids do on a daily basis, they engage in technology. (Physical Therapist Elizabeth, pre-interview, 12/6/2017)

Occupational Therapist Andrea had perceived enhanced student engagement leading to increased student achievement during the implementation of robotics:

> When the technology coordinator started bringing robots into the tech lab, we started bringing kids down here as an alternative activity to what would normally be considered pull out therapy in the therapy room. And it was seen as a way to kind of have another thing in our toolbox that could get the kids excited about their therapy and kind of trick them into doing a lot more work. (Occupational Therapist Andrea, pre-interview, 11/29/2017)

Speech Therapist Olivia perceived interaction with robots as a way to keep students engaged while achieving educational and therapeutic goals:

> I feel like robotics are fun and definitely an engaging activity that you can incorporate into your lesson...We were able to kind of incorporate the robotics into our lesson in a way that it would work to both get interaction with the robot but still get our goals completed (Speech Therapist Olivia, post-interview, 11/30/2017)

Teachers. Six out of six teachers reported that they perceived increased student achievement and engagement during the implementation of robotics. Preschool Teacher Emma spoke of student engagement as "excitement": "I think [students] really enjoyed [robotics] and I think that it does add to the lesson, the excitement of the lesson" (Preschool Teacher Emma, post-interview, 11/8/2017). Teacher Natalie also spoke enthusiastically about increased student engagement during the implementation of robotics:

> I'm definitely pro using technology, and I've seen the difference that it has made, and I think that the fact that it makes the students have more opportunity to be part of the lesson. I think that lessons should be hands-on, students should be doing, they shouldn't be listening, they should be the doers...the students all wanted to take turns and are very interested, and you know that doesn't always happen with everything that you do. (Teacher Natalie, post-interview, 11/14/2017)

Teacher Natalie also spoke of perceiving enhanced student achievement, when students began for the first time to “track” something visually:

> That all boils down to when you bring the robotics into the classroom, and you see the enthusiasm of the students, you see students who, in our school, some of them who are very involved physically, who you've never actually witnessed them ever track something visually and you show them robotics for the first time, and you see them track something is amazing. (Teacher Natalie, post-interview, 11/14/2017)

Primary Teacher Allison had perceived enhanced student engagement:

> When I'm just reading a story to them, they could care less most of the time; their attention is not all there. For some reason, the beeping and the lights and the movement [of the robot] means a lot to them. It doesn't mean that much to me, but it seems to mean a lot to them to keep them engaged and their attention there. (Primary Teacher Allison, post-interview, 11/15/2017)

High School Teacher Sarah spoke of enhanced student achievement as "learning in a playful way," and perceived it to be a result of enhanced engagement associated with the use of robotics:

> I think [students are] engaged and [robotics] gets them on board with the lesson. And they are absolutely excited about learning and participating. They can't wait to have a turn, want to help out, and they seem to be excited to see the robot move, and they learn in a playful way. I love that. (High School Teacher Sarah, post-interview, 11/21/2017)

Middle School Teacher Charlotte spoke of greater student engagement, and spoke of enhanced student achievement as occurring when robotics allowed students to demonstrate their knowledge:

> I think robotics has been very useful in my classroom with my students because it does give them a way to showcase what they know, and it keeps them engaged. And it allowed them to demonstrate what they're learning. (Middle School Teacher Charlotte, pre-interview, 11/19/2017)

Teacher Denise, in a post-observation interview, described the enhanced achievement of an individual student who had used robotics:

> [Student's name omitted] was just more successful with the robotics. I mean he was scoring zeros and ones and two if he was lucky with throwing the ball regular bowling style. Then he went to Dash, and he was able to control the Dash, and I told him to aim for the center pin, and he was scoring fours and fives (see Figure 7). So, it was more successful. (Teacher Denise, post-interview, 11/21/2017)

Five out of six teachers expressed that they themselves had experienced excitement and engagement during the implementation of robotics. Preschool Teacher Emma enthusiastically stated, “I think it's really cool. I'm looking forward to working with them more. I'm excited” (Preschool Teacher Emma, pre-interview, 11/7/2017). High School Teacher Sarah said, “I absolutely love using robotics...I think robotics in everyday life, and definitely lessons is absolutely amazing” (High School Teacher Sarah, pre-interview, 11/18/2017). Primary Teacher Allison spoke of robotics as a motivator for teachers:

> [Robotics are] good for me too because I'm continuously teaching the same concepts and I would get bored you know, learning to identify numbers or whatever the topic is, so I know they get bored with the same old lesson. And when [students are] happy and motivated, I'm happy and motivated to do better for them. (Primary Teacher Allison, pre-interview, 11/14/2017)

Research Question 4

Research question 4 was: What principles of UDL are represented by the implementation of robotics into curricular activities for students with low-incidence disabilities in their classrooms? The following major theme emerged during data analysis to answer research question 4.

Major theme 6: The UDL principles of engagement, representation, and expression were represented by the implementation of robotics. Table 9 indicates the codes that contributed to major theme 6, the number of participants who contributed to each code, and the percentage of participants who contributed to each code.

Table 9

Major Theme 6 Codes and Frequencies

Code	Number of participants who contributed data to code
Engagement	3/3 therapists 6/6 teachers
Expression	3/3 therapists 6/6 teachers
Representation	3/3 therapists 6/6 teachers

Teachers. Researcher observations and teacher interview results indicated that the UDL principles of Provide Multiple Means of Engagement, Provide Multiple Means of Representation, and Provide Multiple Means of Action and Expression were represented by the implementation of robotics in the lessons of six out of six teachers. The principle of engagement was always represented by the use of the robot to "tap into learners' interests, offer appropriate challenges, and increase motivation" (Center for Applied Special Technology [CAST], 2011). In Preschool Teacher Emma's class, robotics was associated with the implementation of UDL principles in the following ways, according to researcher observations:

> Expression: Use of the robot for the student to express their recognition of self.
>
> Representation: Robot can guide information processing, visualization, and manipulation.
>
> Engagement: Robot keeps students engaged in the activity.
>
> (Observational notes, Preschool Teacher Emma's classroom)

Preschool Teacher Emma elaborated on how the lesson contributed to students' ability to generalize as a means of expressing their recognition of self:

> For the purpose of the lesson I want them to find their own face, and then I would like to have them generalize by finding their own face in their cubby when they come in in the morning, and they have to find their cubby to put their belongings away. (Preschool Teacher Emma, pre-interview, 11/7/2017)

Observational notes taken in Teacher Natalie's class indicated that UDL principles were represented in the lesson in the following ways:

> Expression: Student can use the robot to demonstrate knowledge of how blood travels the circulatory system.
>
> Representation: Robot can guide information processing, visualization, and manipulation. Represents the oxygen in the blood.
>
> Engagement: Robot keeps students engaged in the activity.
>
> (Observational notes, Teacher Natalie's classroom)

Teacher Natalie discussed how the lesson implemented expression and representation principles:

> The actual lesson will have different representations because there will be a body that they will be looking at...They will get the opportunity to move around the table so there will be movement involved because they will get to choose what body part that they want the blood to circulate to and move back from. So, there will be a variety of means for them to be involved and to express what is happening and then that will all lead to them using the robotics. (Teacher Natalie, pre-interview, 11/13/2017)

As in the classrooms of Preschool Teacher Emma and Teacher Natalie, researcher observations in the classrooms of Primary Teacher Allison, High School Teacher Sarah, Middle School Teacher Charlotte, and Teacher Denise indicated that the UDL principle of expression was represented by students' controlling robots as a means of expressing the knowledge they had gained during the lesson, "to provide learners options for demonstrating what they know" (Center for Applied Special Technology [CAST], 2011). Primary Teacher Allison spoke of robotics as incentivizing expression for students, in addition to facilitating expression:

> [Students] express themselves and then they have the other students working with them, and they want a turn at the robots. You know they can't get a turn at the robot until they are able to express the goal or the objective of the lesson so then the robot is their reward. (Primary Teacher Allison, pre-interview, 11/14/2017)

The UDL principle of expression was represented through the implementation of robotics in High School Teacher Sarah's lesson in the following way: "I have a student that is nonverbal that can definitely use the iPad to drive a robot to the answer to express themselves" (High School Teacher Sarah, pre-interview, 11/18/2017). Middle School Teacher Charlotte, who used a Sphero robot to retell the voyage of the Mayflower (see Figure 8), indicated that allowing students to guide a Sphero represented the UDL principle of expression: "we'll also be showing action and expression because they'll have to express why they ran into difficulties, how they solved those difficulties and how they made it to safety" (Middle School Teacher Charlotte, pre-interview, 11/19/2017).

In the classrooms of six out of six teachers, researcher observations indicated that the UDL principle of representation was implemented through robotics when the robot was used as an alternative way to represent the curriculum, “to give diverse learners options for acquiring information and knowledge” (Center for Applied Special Technology [CAST], 2011). Observational notes from the classroom of Primary Teacher Allison, for example, indicated that “The robot and the activity represented another way for the teacher to present and reinforce the material being taught.” Primary Teacher Allison, who engaged her students during a math lesson with BeeBot (see Figure 9), confirmed that the principle of representation was implemented in this way:

> [The robot is] not a worksheet. They're not looking at a computer screen. So, it provides a different way of doing addition and subtraction so that they're not doing the same old thing over and over again and they're not bored with it, and they're doing it as a group. (Primary Teacher Allison, pre-interview, 11/14/2017)

Therapists. Researcher observational notes taken during sessions with three out of three therapists (Occupational Therapist Andrea, Speech Therapist Olivia, and Physical Therapist Elizabeth) indicated that the UDL principle of engagement was represented because robotics would, “Engage students in an activity as they are more likely to stay with the activity when they are successful.” The UDL principle of representation was likewise implemented during all three sessions, according to researcher observations. Researcher observations during the sessions with Occupational Therapist Andrea and Speech Therapist Olivia indicated, “The robot represented the letters being taught.” Researcher observations during the session with Physical Therapist Elizabeth indicated, “The robot represented the human that [the student] would have had to follow through the course.” Researcher observations indicated that the UDL principle of expression was represented in sessions with three out of three therapists when students used a robot to express what they had learned. Observational notes from the session with Occupational Therapist Andrea indicated, “Student was able to use the robot to express the letter written.” From the session with Speech Therapist Olivia, observational notes indicated, “Student was able to use the robot to express the correct sequence of the cards.” In Physical Therapist Elizabeth’s session, according to researcher observations, expression was represented in the following way: “Student was able to use the robot to express their understanding of directionality and correct wheelchair operation.” Occupational Therapist Andrea expressed how UDL principles were implemented during the session in the following terms:

> With the Handwriting Without Tears, their big thing is the multiple reasons and actions and expressions. So, it definitely does multiple means of representation. I'm hoping that it also does multiple means of engagement and I think they actually do end up doing multiple means of action and expression because they will have one more thing to do, they'll have another media to do it, I think they get engaged more and you have access to tools and assistive technologies. (Occupational Therapist Andrea, pre-interview, 11/29/2017)

Speech Therapist Olivia also indicated that the three principles of UDL were represented: “Representation, action, and expression because the student will be expressing their answer or knowledge and engagement because that's where the motivation is” (Speech Therapist Olivia, pre-interview, 11/30/2017).

Chapter Summary

Four research questions were used to guide the study. The first research question was: What role does administration play in successful school-wide robotics implementation? Findings indicated that administrators' role involved managing resources to make robotics available, supporting teachers' and therapists' use of robotics by providing training and answering questions, and facilitating innovation in the use of robotics in education.

The second research question was: How do teachers' and therapists' knowledge and implementation of robotics impact the educational and therapeutic IEP goals for students with low-incidence disabilities? Findings indicated that teachers' knowledge and implementation of robotics impacted educational and therapeutic goals by enhancing student engagement and comprehension and that therapists' knowledge and implementation of robotics impacted educational and therapeutic goals by enhancing student motivation and goal attainment.

The third research question was: What patterns emerge in the experiences and perceptions of teachers, therapists, and administrators during the implementation of robotics as an educational and therapeutic tool for students with low-incidence disabilities? Findings indicated that teachers, therapists, and administrators experienced time and funding as constraints during the implementation of robotics and that administrators, therapists, and teachers perceived enhanced student achievement and engagement, and teachers experienced excitement, during the implementation of robotics.

The fourth research question was: What principles of UDL are represented by the implementation of robotics into curricular activities for students with low-incidence disabilities in their classrooms? Findings indicated that the UDL principles of engagement, representation, and expression were represented by the implementation of robotics. Chapter V includes interpretation and implications of these findings.

Chapter V: Discussion of the Findings

Summary of the Study

Federal laws passed over the last 17 years including the No Child Left Behind Act (NCLB, 2001) and more recently Every Student Succeeds Act (ESSA, 2015) have mandated disabled children be not only educated, but also assessed, with the same standards as their non-disabled peers (Browder et al., 2014; Spooner, McKissick, & Knight, 2017). Yet, teachers of children with disabilities are often unprepared and untrained for implementing these new standards into their curricula (Naraian & Surabian, 2014). Some teachers turn to assistive technologies to help students with disabilities perform at federally-mandated standards as well as to help students with disabilities have the same educational opportunities and experiences of non-disabled children (DeCoste, 2013; Fichten, Asuncion, & Scapin, 2014). Assistive technologies, specifically robotics, have increased class participation, computer access, communication function, and improved mobility with wheelchair advancements and prosthetics (Benitti, 2012; Isaacson, Schleppenbach, & Lloyd, 2014; Izzo & Bauer, 2015).

The problem is that despite federal mandates of increased performance of children with disabilities, teachers are not adequately trained on the implementation of assistive technology such as robotics, which has been shown to improve curricular development and performance for students with disabilities (Benitti, 2012; Jones, 2015). Robotics, in particular, is understudied for its impact on curricular for students with disabilities. The current study addressed the specific problem of understanding the implementation and perceptional impact of robotics for the education and therapeutic goals of students classified with low-incidence disabilities. The purpose of this exploratory case study was to explore these perceptions by evaluating teacher, therapeutic, and administrative knowledge, implementation, and perceptions of the use of robotics for students with low-incidence disabilities. The evaluation was done through observation of teacher and therapists at the A. Harry Moore School in Jersey City, New Jersey, a well-recognized school for its use of robotics with students with disabilities. In addition to observations, interviews were conducted with six teachers, three therapists, and two administrators. The researcher then used Yin's (2013) five-phased cycle for coding case study data, which involved compiling, disassembling, reassembling, interpreting, and concluding. The results of this study provide an understanding and practices of how robotics can be implemented into the educational programs of students with low-incidence disabilities. This chapter will provide a summary of the findings, a discussion and interpretation of the findings, the implications of findings, the limitations of the study, recommendations for future research, and a chapter summary.

Summary of the Findings

The purpose of this exploratory case study was to investigate how the use of robotics can support the educational and therapeutic goals of students with low-incidence disabilities. Guided by the following research questions, this study explored the roles and perceptions of 2 administrators, three therapists, and six teachers:

1. What role does administration play in successful school-wide robotics implementation?

2. How do teachers' and therapists' knowledge and implementation of robotics influence the attainment of educational and therapeutic IEP goals for students with low-incidence disabilities?

3. What patterns emerge in the experiences and perceptions of teachers, therapists, and administrators during the implementation of robotics as an educational and therapeutic tool for students with low-incidence disabilities?

4. What principles of UDL are represented by the implementation of robotics into curricular activities for students with low-incidence disabilities in their classrooms?

Based on these questions, six major themes emerged in the findings: (1) administrators' role involved managing resources to make robotics available, supporting teachers' and therapists' use of robotics by providing training and answering questions, and facilitating innovation in the use of robotics in education; (2) teachers' knowledge and implementation of robotics impacted educational and therapeutic goals by enhancing student engagement and comprehension; (3) therapists' knowledge and implementation of robotics impacted educational and therapeutic goals by enhancing student motivation and goal attainment; (4) teachers, therapists, and administrators experienced time and funding as constraints during the implementation of robotics; (5) administrators, therapists, and teachers perceived enhanced student achievement and engagement, and teachers experienced excitement, during the implementation of robotics. Each of these themes are discussed below in more depth and in relation to the previous literature.

Administrators' role involved managing resources to make robotics available, supporting teachers' and therapists' use of robotics by providing training

and answering questions, and facilitating innovation in the use of robotics in education. This was an important finding from the current study as administrators have often been overlooked by the literature or grouped together under the term educator (Vidacek-Hains, Kozina & Kirinic, 2016). While research has shown the importance of resources in facilitating the educational and therapeutic needs of children with disabilities, the specific role of school administrators has not been clearly understood nor appreciated (Vidacek-Hains, Kozina & Kirinic, 2016). This study found that administrators have an important position in the acquisition and implementation of robotics as well as assisting teachers and therapists with information and training as well as facilitating innovation in the classroom by making robotics available through the allocation of resources and encouraging experimentation as well as assistance for other teachers. This study suggests that the lack of understanding around the administrators' impact and perception of robotics could hurt the implementation of robotics or other assistive technologies in school curricula. Therefore, this study's finding also suggests more research should address the importance of administrators in implementing assistive technologies in school curricula.

Teachers' knowledge and implementation of robotics impacted educational and therapeutic goals by enhancing student engagement and comprehension. This theme echoed previous research by indicating the importance of teacher's knowledge of assistive technologies in general for engaging students with disabilities but also how specific disabilities may need special technological adaptation (Basak & Govender, 2015; Soorenian; 2014; Sachdeva et al., 2015). Huijen, Lexis, Jansens and de Witte (2016) found that specific disabilities or conditions need to be recognized as requiring specific attributes in the robotics themselves. For example, robotic used with autistic students should contain human characteristics, but more specifically, robots should wear clothing similar to the specific student and should speak slowly and quietly (Huijen, Lexis, Jansens & De Witte, 2016). Soorenian (2014) emphasized the needs for teachers to be knowledgeable about the specific technologies and how they will interact with the specific needs of individual children. The current study also found that teacher knowledge and implementation of robotics can only enhance a student's education, engagement, and comprehension if the fit between student and technology makes sense. This can be achieved through experimentation and innovation.

Therapists' knowledge and implementation of robotics impacted educational and therapeutic goals by enhancing student motivation and goal attainment. The current study found that simply employing robotics increased student motivation because the use of the technology was enjoyable and fun for the student, thereby increasing student engagement and goal attainment. This finding supports previous literature, which also found that robotics can increase enjoyment and engagement which can help motivate students with disabilities (Adams & Cook, 2014; Barker, 2014; Hawon & Eunja, 2015). For example, Adams and Cook (2014) found that Lego Mindstorm robots were not only useful but also a fun way for students to learn and thus increased motivation. The current study found that motivation and goal attainment could be increased by involving elements of play such as obstacle courses (Observational notes, session with Physical Therapist Elizabeth). Therapeutic goals of finger isolation, fine motor skills, and pincer grasp were met using robotics in a letter tracing exercise, which employed robotics as a motivator (Observational notes, session with Speech Therapist Olivia). This use of robotics as a motivator is important for reaching therapeutic and educational goals because it increases engagement through fun and enjoyable activities (Adams & Cook, 2014; Barker, 2014; Hawon & Eunja, 2015).

Teachers, therapists, and administrators experienced time and funding as constraints during the implementation of robotics. Funding has been shown to be a burden in the previous literature as assistive technologies and robotics can be expensive to implement for families and educational institutions (Alterobvitz, Koenig & Likhachev, 2016; Vidacek-Hains, Kozina & Kirinic, 2016). Research has also shown that the upfront cost of assistive technologies is justified by avoiding later costs due to the effectiveness of assistive technologies (Alterobvitz, Koenig & Likhachev, 2016). Likewise, the time spent learning and training on the part of educators in regard to assistive technologies greatly increases the speed and performance of students with disabilities (Basak & Govender, 2015; Messinger-Willman & Marino, 2010). Participants in the current study suggested that if more time was spent up front learning the various technologies, then more time would have been saved in the classroom during actual lessons (Preschool Teacher Emma, post-interview, 11/8/2017). The current study supports the previous research that time and money are leading constraints for implementing assistive technologies, specifically robotics. As previous research suggests, the initial time and costs are far outweighed by the long-term payback of the technologies and robotics (Alterobvitz, Koenig & Likhachev, 2016; Preschool Teacher Emma, post-interview, 11/8/2017; Vidacek-Hains, Kozina & Kirinic, 2016).

Administrators, therapists, and teachers perceived enhanced student achievement and engagement, and teachers experienced excitement, during the

implementation of robotics. Similar to the major theme that identified enhanced motivation and goal attainment, the current study also found increased engagement of students with disabilities through pleasure, enjoyment, and fun (Preschool Teacher Emma, post-interview, 11/8/2017; Speech Therapist Olivia, post-interview, 11/30/2017; Physical Therapist Elizabeth, pre-interview, 12/6/2017). This increased engagement through enjoyment and excitement supported the previous literature. Research has shown that engagement increases through enjoyment, pleasure, and excitement with the activity, which can be enhanced by the implementation of technology and robotics (Adams & Cook, 2014; Barker, 2014; Hawon & Eunja, 2015). Edyburn (2005) specifically found that multiple means of engagement increased students' success and robotics have been found to increase the means in which students are engaged (Adams & Cook, 2014; Barker, 2014; Hawon & Eunja, 2015; Hedgecock et al., 2014; Robins et al., 2005; Tapus et al., 2012). Furthermore, the utilization and implementation of robotics has been shown to increase the engagement and enjoyment of educators, which in turn can benefit students (Teacher Natalie, post-interview, 11/14/2017; Primary Teacher Allison, post-interview, 11/15/2017; Teacher Denise, post-interview, 11/21/2017; Middle School Teacher Charlotte, post-interview, 11/22/2017).

The UDL principles of engagement, representation, and expression were represented by the implementation of robotics. This theme was important for providing further evidence for the theoretical framework of Universal Design for Learning (UDL). UDL stresses the importance of engagement and the current study supported the use of robotics to increase engagement, which has been demonstrated in the above theme. The UDL also stresses representation, which was also present in the findings of the current study. For example, all six teachers interviewed indicated representation was present through a robot's alternative way to represent the curriculum.

Discussion

Assistive technologies have long been utilized for enhancing the educational experience of students with various disabilities (Basak & Govender, 2015; Yook & Kim, 2015). Specifically, Soorenian (2014) found that assistive technologies reduced student dependency on others for support as well as increasing performance levels. Most research suggests that assistive technologies can decrease the divide between disabled and non-students with disabilities, though special consideration needs to be paid to the specific needs associated with each type of disability and each individual student (Sachdeva et al., 2015; Soorenian, 2014; Vidacek-Hains, Kozina & Kirinic, 2016). Robotics have been shown to greatly enhance the motivation and learning of children with ASD (Alley-Young; 2016; Huijen, Lexis, Jansens & de Witte, 2016; Tadesse, Wu & Saharan, 2016). For example, researchers found that the humanistic design of robots was particularly beneficial for children with ASD (Tadesse, Wu & Saharan, 2016). While the usefulness of robotics is well-documented for children with ASD, the benefits of robotics on children with low-incidence disabilities is less studied and understood (Alley-Young, 2016; Hedgecock et al., 2014; Huijen, Lexis, Jansens & de Witte, 2016; Tadesse, Wu & Saharan, 2016).

The current study extended knowledge on the benefits of assistive technologies for children with disabilities. Specifically, this study addressed the gap in the literature, which was how little is known about teacher, therapeutic, and administrative knowledge, implementation, and perceptions of the use of robotics for students with low-incidence disabilities. For example, the current study found that teacher, therapist, and administrators perceived the use of robotics by students with low-incidence disabilities as a way to increase motivation, goal attainment, enjoyment, engagement, and comprehension. These findings confirmed previous research, which had shown how assistive technologies benefit children with disabilities (Adams & Cook, 2014; Barker, 2014; Hawon & Eunja, 2015; Huijen, Lexis, Jansens & de Witte, 2016; Tadesse, Wu & Saharan, 2016).

The current study provided insight and evidence for the important role of administrators in the implementation and facilitation of robotics for children with low-incidence disabilities. No other studies have specifically examined the perceptions and impact of administrators on robotics use for children with disabilities. This study revealed that administrators help manage the resources that make it possible to obtain robotic technologies and are there for a crucial consideration for schools and curricula. Furthermore, administrators help teachers implement technologies by providing training and knowledge pertaining to the technology. They help answer questions and encourage innovation through experimentation.

In addition to the administrative role, the current study also provided data on the perceptions of teachers and therapists, those most likely to implement and supervise the interaction of children with disabilities and the robotic technologies. This provided insight into the best practices and barriers for implementing robotic technologies to help children with low-incidence disabilities

The current study used two theoretical frameworks to guide its research: The Technology Acceptance Model (TAM), developed by Davis (1985) and the Universal

Design for Learning (UDL) developed by David Rose and Anne Meyer in 1997 (Edyburn, 2005). TAM states that individuals are less likely to utilize technology if they lack the skills or technological confidence required to use that technology (Davis, 1985). This principle was supported and advanced by the current study, which found that a teacher's knowledge and understanding greatly enhanced the understanding and engagement of that technology of students with low-incidence disabilities. Meaning, not only is a teacher more likely to incorporate robotic technology if she understands how to use it but is more likely to engage her students with that technology as well. By understanding robotic technology better, therapists and educators are better equipped to help their students build the understanding and confidence require to use and benefit from that technology as suggested by TAM (Davis, 1985).

Furthermore, evidence supporting UDL was a reoccurring theme within the results and findings of the current study. The three primary UDL principles of providing multiple means of engagement, expression, and representation were all common themes within the data collected through interviews with the participants. The current study provided support for the three UDL principles in the following three ways: (1) use of a robot for the student to express their recognition of self; a robot can guide information processing, visualization, and manipulation; robot keeps students engaged in the activity (Observational notes, Preschool Teacher Emma's classroom). This lends further validity for using UDL as a theoretical framework as a useful guide for future research on implementing robotics to assist students with disabilities.

Previous research used various methods and research designs to investigate assistive technologies and how they benefit students with disabilities, however, not many case studies have been done. While few case studies were found in the review of the literature, the potential benefit and usefulness is clearly shown through the present study for providing a framework for implementation and facilitation of robotics in order to support children with low-incidence disabilities. Specifically, case studies allow a researcher to gather multiple forms of data from such things as interviews and observations for exploratory purposes of understanding the how and why of something (Yin, 2013). For example, Adams and Cook (2014) used a case study of a single child for the application of Lego robots in the education of children with disabilities. This case study showed that robots gave the child comparable educational benefits to that of a non-disabled child. The use of a case study was crucial to understanding how well a student could participate in activities when using the assistive technology of a robot. Gathering intimate details from a case study allows a researcher to encounter the unknown and unforeseen elements (Adams & Cook, 2014; Yin, 2013). Similarly, the current case study allowed this researcher the ability to see the challenges and opportunities associated with implementing robotics into school curricula.

While few case studies were identified in the previous research, several studies employed qualitative methods using interviews to collect data (Seale, Georgeson, Mamas, & Swain, 2015; Soorenian, 2014; Tsui, McCann, McHugh, Medvedev, Yanco, Kontak, & Drury, 2014). Interviews allow for the collection of rich data necessary for qualitative exploratory studies (Creswell, 2014; Soorenian, 2014; Tsui, McCann, McHugh, Medvedev, Yanco, Kontak, & Drury, 2014). For example, interviews allowed Soorenian (2014) to explore the benefits and challenges of assistive technologies with disabled children. This allowed Soorenian (2014) to understand how assistive technologies can help bridge the gap between disabled and non-students with disabilities. The current study also used interviews for similar purposes, collecting rich exploratory data to understand how teachers, administrators, and therapists work with robotics to assist students with low-incidence disabilities. Seale, Georgeson, Mamas, and Swain (2015) also used interviews with disabled college students. The use of interviews allowed them to uncover that while most students with disabilities used assistive technology, the technology used varied greatly across specific disability and personal preference. These kinds of details are crucial to exploratory studies seeking to gather as much understanding as possible. The current study utilized interviews in order to add the perceptions and experiences of educators to the body of literature on assistive technologies for students with low-incidence disabilities. This study found educators need adequate training, knowledge, and resources in order to obtain, implement, and facilitate the use of robotics. Furthermore, this study found that properly implemented, educators believe robotics may greatly aid in the addressing the unique challenges faced by students with low-incidence disabilities and the professionals tasked with their education.

Implications

This case study explored the perceptions and impact of administrators, teachers, and therapists on the implementation and facilitation of robotics for assisting students with low-incidence disabilities at the A. Harry Moore School. The study's results have numerous implications for positive social change through practice and policy as well as theoretical implications for the use of both TAM and UDL frameworks.

The implications for positive social change exist on the individual, family, and societal level. The current study found that the use of robotics aided educators in improving the motivation, engagement, enjoyment, and performance in the academic setting of students with low-incidence disabilities. While assistive technologies have been well documented as a positive influence for students with disabilities, and likewise robotics has been well documented as a positive influence for students with autism, the impact of robotics on students with low-incidence disabilities had not been well documented especially from the perspective of educators (Alley-Young, 2016; Basak & Govender, 2015; Huijen, Lexis, Jansens & de Witte, 20176; Soorenian; 2014; Sachdeva et al., 2015). This means that this study provided insight and knowledge to this area in a particularly practical method. The use of case study design revealed that administrators, therapists, and teachers perceived that their students with low-incidence disabilities were positively impacted through implementing robotics into the curricula. Furthermore, this study indicated that educators need the resources and knowledge to facilitate learning through the use of robotics. This study is important for educators at every level, for without their knowledge and enthusiasm, successful implementation of robotics would not be possible. Educators face unique challenges when working with students with low-incidence disabilities. This study found that the use of robotics may help educators meet those challenges in a positive and engaging manner for all involved.

It may, therefore, be possible to improve the educational experience and quality of life for individuals with low-incidence disabilities. By providing more independence to individuals with disabilities, their engagement with and quality of life could be greatly enhanced (Alley-Young, 2016; Poel, Wood, & Schmidt, 2013; Smith et al., 2016).

By improving the educational experience and quality of life of individuals with low-incidence disabilities, there is the possibility of improving the quality of life for the families of those with disabilities (Alley-Young, 2016; Poel, Wood, & Schmidt, 2013; Soorenian; 2014). As robotics has the ability to help individuals with low-incidence disabilities gain independence, it could alleviate the demands of time and resources on family members (Alley-Young, 2016; Poel, Wood, & Schmidt, 2013). This increased independence of individuals with low-incidence disabilities could then also lessen the number of resources needed from society as well, allowing these individuals to more fully engage and contribute to society as a whole (Alley-Young, 2016; Poel, Wood, & Schmidt, 2013; Smith et al., 2016). Specifically, by giving more independence and opportunity to individuals with disabilities, perhaps society will recognize the unique abilities and contributions that these individuals bring to society.

While this study was exploratory based, meaning its design was meant to gather as much rich data as possible, it does add validity and evidence of usefulness for its guiding theoretical frameworks of TAM and UDL. As suggested by TAM, the study was consistent with the theory in that results suggest that individuals are more likely to accept and utilize technology if they possess enough knowledge and technology (Davis, 1985). Specifically, the study found that knowledge and confidence of robotic use with teachers, therapists, and administrators help facilitate the implementation and increase utilization of robotics in education for students with low-incidence disabilities. Furthermore, the current study supported UDL by highlighting how three main principles of the theoretical framework, engagement, representation, and expression were present in the A. Harry Moore School in Jersey City. UDL seeks to provide a framework that helps all students, even students with disabilities, an equal educational opportunity (Basham et al., 2010; Rose & Meyer, 2002). The current study supported the UDL framework as relevant and useful for the success of students with low-incidence disabilities by promoting engagement, expression, and representation through the use of robotics.

While there are implications for positive social change and the theoretical frameworks of TAM and UDL, perhaps the most important implications of the current study are to be found in practice. Schools and educators may be especially interested in the findings of the current study especially those who work with students who have disabilities. This study offers important considerations for best practices when trying to implement assistive technologies, specifically robotics, to aid students with disabilities.

Limitations of the Study

The primary limitation of the study comes from the inherent design of a qualitative case study. A qualitative case study was the strongest design for the purpose of the study, to explore the impact and perceptions of educators on the implementation of robotics to assist students with disabilities, however, case studies lack generalizability and causality. A primary limitation of case studies is small sample size. The current study was limited to 11 total participants in order to complete the study in a timely manner though, the participants may not be representative of the general population of educators working with students with low-incidence disabilities. Despite the range of disabilities represented at the A. Harry Moore School, the current study did not focus on specific disabilities to maintain the anonymity of students. While the lack of categorization of disabilities limited the studies application to specific disabilities, it allowed the researcher to protect the identity of students attending the A. Harry Moore

School. Furthermore, the sample for this study was limited to one school and from teachers and therapists who educate students with low-incidence disabilities and are therefore not representative of all special education teachers and therapists or regular public schools.

Another limitation of the study was the focus on the use of small, low-cost robotics for curricular implementation and thus cannot be generalized to all robotics such as humanoid robots. Furthermore, the use of interviews was assumed to be reliable, that is that participants were honest and thoughtful with their answers, but there is no certainty of trustworthiness in such assessments. The use of interviews also can make interpretation via data triangulation difficult due to so many differing opinions (Hodkinson & Hodkinson, 2001). Finally, the researcher's personal biases, familiarity with the research participants, and the time constraints imposed by the doctoral program limited the scope of the study.

Recommendations for Further Research

Based on the strengths of the current study coupled with the previous literature, the researcher recommends more research investigating the benefits robotics have on low-incidence disabilities. As the current study revealed through its literature review, there is a deficit of studies on the impact, benefit, and perceptions of robotics on students with low-incidence disabilities.

Based on the limitations, the current study has several recommendations for the design of future research: (1) increasing sample size; (2) expand research to look at specific needs of specific disabilities; (3) explore the impact of humanoid robots on the educational experience of students with low-incidence disabilities; and (4) designing a quantitative study to measure how much improvement occurs after implementing robotics in aiding students with disabilities. Each of these adjustments to study design would enhance the problem identified by the current study, which is the lack of knowledge and research around the use of robotics with low-incidence disabilities. The more varied research on the use of diverse types of robotics on diverse student populations with diverse types of disabilities will help fill the gap in the literature. Additionally, future researhers should delve further into the specifics of Universal Design for Learning. Looking into providing options for executive functioning, self regulation and language accquisition will enhance the study. Addressing the problem of lack of research could help improve the educational experience for students with disabilities including increased performance, motivation, engagement, enjoyment, and independence. These improvements could improve the well-being of individuals with disabilities as well as their families (Alley-Young, 2016; Poel, Wood, & Schmidt, 2013; Seale, Georgeson, Mamas, & Swain, 2015; Smith et al., 2016; Soorenian, 2014; Tsui, McCann, McHugh, Medvedev, Yanco, Kontak, & Drury, 2014). Furthermore, the more independence and education for an individual with disabilities means more contribution and integration with society (Alley-Young, 2016; Poel, Wood, & Schmidt, 2013; Smith et al., 2016).

Chapter Summary

Chapter 5 concludes this qualitative case study, the purpose of which was to explore how the use of robotics can support the educational and therapeutic goals of students with low-incidence disabilities. Under the direction of the two guiding theoretical frameworks, it was expected that technology would be better accepted with increased knowledge and confidence. It was also expected that the principles of UDL would be present in the A. Harry Moore School in Jersey City, New Jersey. Both expectations were confirmed by the current study. The gap in the previous literature, the lack of studies on the impact and perception of robotics used to assist students with low-incidence disabilities was addressed, and as expected from the literature, the current study suggests the need for ongoing research in this area.

The study found that therapists, teachers, and administrators perceive that students with low-incidence disabilities can be positively impacted by the implementation of robotics. Specifically, educators believe robotics improved motivation, engagement, performance, and enjoyment thereby increasing educational success and well-being among students. In order to increase student engagement and performance, educators including therapists, teachers, and administrators must be knowledgeable and educated about robotics. Assisting students with disabilities is necessary to ensure their quality of life. Furthermore, teachers, administrators, and therapists have the ability to help students meet the federal mandates to perform at the level of their non-disabled peers. Robotics may be one tool that can assist educators in meeting the goals of their students, but educators must first be properly trained as well as engaged with robotics themselves before they will be able to aid the learning process for their students. By increasing the independence and educational opportunities for students with disabilities, robotics have the capacity to enhance students' lives and contribution to society. How much impact robotics have on students with disabilities remains uncertain and an area of important ongoing research.

References

Adams, K. D., & Cook, A. M. (2014). Programming and controlling robots using scanning on a speech generating communication device: A case study. *Technology & Disability*, *26*(1), 49-59. doi:10.3233/TAD-140404

Ajuwon, P. M., Sarraj, H., Griffin-Shirley, N., Lechtenberger, D., & Zhou, L. (2015). Including students who are visually impaired in the classroom: Attitudes of preservice teachers. *Journal of Visual Impairment & Blindness*, *109*(2), 131-140.

Alimisis, D. (2013). Educational robotics: Open questions and new challenges. *Themes in Science & Technology Education*, *6*(1), 63-71.

Alkahtani, K. D. F. (2013). Teachers' knowledge and use of assistive technology for students with special educational needs. *Journal of Studies in Education*, *3*(2), 65-86.

Alley-Young, G. (2016). Technology tools for students with autism: Innovations that enhance independence and learning. *Canadian Journal of Communication, 41*(3), 520-522. Retrieved from http://www.cjc-online.ca/index.php/journal

Alterovitz, R., Koenig, S., & Likhachev, M. (2016). Robot planning in the real world: Research challenges and opportunities. *AI Magazine, 37*(2), 76-84. Retrieved from http://ai-magazine.com/

Americans with Disabilities Act of 1990, as Amended, 42 U.S.C §12101 et esq. (1990)

Aresti-Bartolome, N., & Garcia-Zapirain, B. (2014). Technologies as support tools for persons with autistic spectrum disorder: A systematic review. *International Journal of Environmental Research and Public Health, 11*(8), 7767-802.

Barba, R. (2015, January 8). Top 5 kids educational robots at CES 2015. Retrieved April 18,2016, from http://tech.co/top-5-kids-educational-robots-ces-2015-2015-01

Barker, I. (2014). The future's bright: the future is robots. *TES: Times Educational Supplement*, (5097), 7-8. Retrieved from https://www.tes.com/en-us/

Barros, R. P., Burlamaqui, A. M. F., de Azevedo, S. O., de Lima Sa, S. T., Goncalves, L. M. G., & da Silva, A. A. R. S. (2017). Cardbot-assistive technology for visually impaired in educational robotics: Experiments and results. *IEEE Latin America Transactions*, *15*(3), 517-527.

Basak, S. K., & Govender, D. W. (2015). Development of A conceptual framework regarding the factors inhibiting teachers' successful adoption and implementation of ICT in teaching and learning. *The International Business & Economics Research Journal (Online), 14*(3), 431. Retrieved from https://cluteinstitute.com/ojs/index.php/IBER

Basham, J.D., Israel, M., Graden, J, Poth, R., & Winston, M. (2010). A comprehensive approach to RTI: Embedding universal design for learning and technology. *Learning Disability Quarterly*, 33(4), 243-255.

Benitti, F. B. V. (2012). Exploring the educational potential of robotics in schools: A systematic review. Computers & Education, 58(3), 978.

Bee-Bot teacher's guide. (n.d.). Retrieved from https://www.tts-group.co.uk/on/demandware.static/-/Sites-TTSGroupE-commerceMaster/default/dw93aafc4e/images/document/1001794_00_EL00363%20Bee-Bot%20-%20Teacher%20Guide%20.pdf

Bers, M. U. (2008). Blocks to robots. New York, NY: Teachers College Press.

Birt, L., Scott, S., Cavers, D., Campbell, C., & Walter, F. (2016). Member checking: A tool to enhance trustworthiness or merely a nod to validation? *Qualitative Health Research*, *26*(13), 1802-1811.

Blackwell, C. K., Wartella, E., Lauricella, A. R., & Robb, M. B. (2015). *Technology in the lives of educators and early childhood programs; Trends in access, use, and professional development from 2012 to 2014*. Latrobe, PA: The Fred Rogers Center for Early Learning and Media at Saint Vincent College.

Brand, S. T., & Dalton, E. M. (2012). Universal design for learning: Cognitive theory into practice for facilitating comprehension in early literacy. Forum on Public Policy: A Journal of the Oxford Round Table.

Browder, D. M., Wood, L., Thompson, J., & Ribuffo, C. (2014). *Evidence-based practices for students with severe disabilities* (Document No. IC-3). Retrieved from University of Florida, Collaboration for Effective Educator, Development, Accountability, and Reform Center website: http://ceedar.education.ufl.edu/tools/innovation-configurations/

CAST (2011). Universal Design for Learning Guidelines version 2.0. Wakefield, MA: Author. www.cast.org

Cominelli, L., Carbonaro, N., Mazzei, D., Garofalo, R., & Tognetti, A. (2017). A multimodal perception framework for users' emotional state assessment in social robotics. *Future Internet, 9*(13), 42. Retrieved from http://www.mdpi.com/journal/futureinternet

Conti, D., Commodari, E., & Buono, S. (2017). Personality factors and acceptability of socially assistive robotics in teachers with and without specialized training for children with disability. *Life Span and Disability*, *20*(2), 251-272.

Creswell, J. W. (2014). *Research design: Qualitative, quantitative, and mixed methods approaches* (4th. ed.). Thousand Oaks, CA: Sage.

Damiani, P., & Ascione, A. (2017). Body, movement and educational robotics for students with Special Educational Needs. *Italian Journal of Educational Research*, *10*(18), 43-58.

Davis, F. D. (1985). *A technology acceptance model for empirically testing new end-user information systems: Theory and results* (Doctoral dissertation, Massachusetts Institute of Technology).

DeCoste, D. C. (2011). A note from the chair of the task force [Introduction]. In *A route for every learner: Universal design for learning (UDL) as a framework for supporting learning and improving achievement for all learners in Maryland, prekindergarten through higher education* (ii). Baltimore, MD: Maryland State Department of Education.

DeCoste, D. C. (2013). The changing roles of assistive technology teams in public school settings. *Perspectives on Language and Literacy*, *39*(4), 19-24.

Downing, J. E. & MacFarland, S. (2010) Education and individuals with severe disabilities: Promising practices. *International Encyclopedia of Rehabilitation*.

Edyburn, D. L. (2003). Introduction to the special issue: Insights into the effective and appropriate use of technology in special education. *Remedial and Special Education*, *24*(3), 130-131.

Edyburn, D. L. (2005). Universal design for learning. *Special Education Technology Practice*, *7*(5), 16-22. Retrieved from http://www.setp.net/

Erickson, F. (2012). Qualitative research methods for science education. In B.J. Fraser, K. G. Tobin, & C. J. McRobie (Eds). *Second international handbook of science education* (pp. 1451–1469). Dordrech, The Netherlands: Springer Netherlands.

ESSA (2015). Every Student Succeeds Act of 2015, Pub. L. No. 114-95 § 114 Stat. 1177 (2015-2016).

Fichten, C. S., Asuncion, J., & Scapin, R. (2014). Digital Technology, Learning, and Postsecondary Students with Disabilities: Where We've Been and Where We're Going. *Journal of Postsecondary Education and Disability*, *27*(4), 369-379.

Fylan, F. (2005). Semistructured interviewing. In J. Miles & P. Gilbert (Eds.), *A handbook of research methods for clinical and health psychology* (pp. 65–78). Oxford, England: Oxford University Press.

Grasmick, N. S. (2011). A letter from the state superintendent of schools [Introduction]. In *A route for every learner: Universal design for learning (UDL) as a framework for supporting learning and improving achievement for all learners in Maryland, prekindergarten through higher education* (i). Baltimore, MD: Maryland State Department of Education.

Gray, D. E. (2009). *Doing research in the real world*. Thousand Oaks, CA: Sage

Grynszpan, O., Weiss, P. L., Perez-Diaz, F., & Gal, E. (2014). Innovative technology-based interventions for autism spectrum disorders: a meta-analysis. *Autism*, *18*(4), 346-361.

Hawon, L., & Eunja, H. (2015). The Intelligent Robot Contents for Children with Speech-Language Disorder. *Journal of Educational Technology & Society*, *18*(3), 100-113. Retrieved from http://www.ifets.info/

Hayden, S. (2011). *Enabling curricula: The development of a teaching observation protocol to address students' diverse learning needs* (Order No. 3498141). Available from ProQuest Dissertations & Theses Global. (925788184). Retrieved from https://search.proquest.com/docview/925788184?accountid=12793

Hayes, H. B. (2013, March 28). How technology is helping special-needs students excel. Retrieved June 03, 2017, from https://edtechmagazine.com/k12/article/2013/03/how-technology-helping-special-needs-students-excel

Hedgecock, J., Standen, P. J., Beer, C., Brown, D., & S. Stewart, D. (2014). Evaluating the role of a humanoid robot to support learning in children with profound and multiple disabilities. *Journal of Assistive Technologies, 8*(3), 111.

Heinrich, S., Knight, V., Collins, B. C., & Spriggs, A. D. (2016). Embedded simultaneous prompting procedure to teach STEM content to high school students with moderate disabilities in an inclusive setting. *Education and Training in Autism and Developmental Disabilities*, *51*(1), 41-54.

Hodge, M., & Welch, J. (2016). An implementation perspective: Relevant lessons from no child left behind (NCLB) for the implementation of every student succeeds act (ESSA). *Journal of Ethical Educational Leadership, 3*(9), 1-17.

Hodkinson, P. & Hodkinson, H. (2001). The strengths and limitations of case study research. Paper presented to the Learning and Skills Development Agency conference: Making an Impact on Policy and Practice. Cambridge.

Hourigan, R. M. (2014). Intersections between school reform, the arts, and special education: the children left behind. *Arts Education Policy Review*, *115*(2), 35-38.

Huijnen, Claire A. G. J., Lexis, M. A. S., Jansens, R., & de Witte, L. P. (2016). Mapping robots to therapy and educational objectives for children with autism spectrum disorder. *Journal of Autism and Developmental Disorders*, *46*(6), 2100-2114. doi:10.1007/s10803-016-2740-6

Ibrahim, M. S., Razak, A. Z. A., & Kenayathulla, H. B. (2013). Smart principals and smart schools. *Procedia - Social and Behavioral Sciences, 103*, 826-836. https://doi.org/10.1016/j.sbspro.2013.10.404

Individuals with Disability Education Act Amendments of 1997 [IDEA]. (1997). Retrieved from http://thomas.loc.gov/home/thomas.php

Individuals with Disabilities Education Improvement Act of 2004, 20 U.S.C. § 1400 et seq. No Child Left Behind (NCLB) Act of 2001, Pub. L. No. 107-110, § 115, Stat. 1425 (2002). (2004) (reauthorization of the Individuals with Disabilities Education Act of 1990)

Isaacson, M. D., Schleppenbach, D., & Lloyd, L. (2014). Increasing STEM accessibility in students with print disabilities through MathSpeak. *Journal of Science Education for Students with Disabilities*, *14*(1), 25-32.

Izzo, M. V., & Bauer, W. M. (2015). Universal design for learning: enhancing achievement and employment of STEM students with disabilities. *Universal Access in the Information Society*, *14*(1), 17-27.

Jain, S., & Chavan, B. S. (2017). Effect of Smart Board Technology on Learning Environmental Science among Children with Intellectual Disability. *Journal of Disability Management and Rehabilitation*, *1*(1), 17-20. Retrieved from http://www.jdmronline.org/index.php/jdmr/about

Jones, S. K. (2015). Teaching students with disabilities: A review of music education research as it relates to the Individuals with Disabilities Education Act. *Update: Applications of Research in Music Education*, *34*(1), 13-23.

Kaboski, J. R., Diehl, J. J., Beriont, J., Crowell, C. R., Villano, M., Wier, K., & Tang, K. (2015). Brief report: A pilot summer robotics camp to reduce social anxiety and improve social/vocational skills in adolescents with ASD. *Journal of autism and developmental disorders*, *45*(12), 3862-3869.

Kanno-Youngs, Z. (2016). Tech helps students with disabilities soar at Jersey City school; A. Harry Moore supplements special education with technology. *Wall Street Journal (Online)*

Khanlari, A. (2013). Effects of robotics on 21st century skills. *European Scientific Journal*, *9*(27), 26.

Kim, E. S., Berkovits, L. D., Bernier, E. P., Leyzberg, D., Shic, F., Paul, R., & Scassellati, B. (2013). Social robots as embedded reinforcers of social behavior in children with autism. *Journal of Autism and Developmental Disorders, 43*(5), 1038-1049. doi:10.1007/s10803-012-1645-2

Kleinert, H., Towles-Reeves, E., Quenemoen, R., Thurlow, M., Fluegge, L., Weseman, L., & Kerbel, A. (2015). Where students with the most significant cognitive disabilities are taught: Implications for general curriculum access. *Exceptional Children*, 81(3), 312-328. Retrieved from https://search.proquest.com/docview/1737519210?accountid=12793

Ko, A. J., & Ladner, R. E. (2016). Access Computing Promotes Teaching Accessibility. *ACM Inroads*, *7*(4), 65-68.

Lee, J., Takehashi, H., Nagai, C., Obinata, G., & Stefanov, D. (2012). Which robot features can stimulate better responses from children with autism in robot-assisted therapy? *International Journal of Advanced Robotic Systems, 9*, 72.

Leopold, A., Lourie, A., Petras, H., & Elias, E. (2015). The use of assistive technology for cognition to support the performance of daily activities for individuals with cognitive disabilities due to traumatic brain injury: The current state of the research. *NeuroRehabilitation*, *37*(3), 359-378.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Thousand Oaks, CA: Sage.

Lindsay, S., & Hounsell, K. G. (2017). Adapting a robotics program to enhance participation and interest in STEM among children with disabilities: a pilot study. *Disability and Rehabilitation: Assistive Technology*, *12*(7), 694-704.

Mechling, L. C., Ayres, K. M., Foster, A. L., & Bryant, K. J. (2015). Evaluation of generalized performance across materials when using video technology by students with autism spectrum disorder and moderate intellectual disability. *Focus on Autism and Other Developmental Disabilities, 30*(4), 208-221. Retrieved from http://journals.sagepub.com/home/foa

Merriam, S. B. (1998). *Qualitative research and case study applications in education*. San Francisco: Jossey-Bass.

Messinger-Willman, J., & Marino, M. (2010). Universal design for learning and assistive technology: Leadership considerations for promoting inclusive education in today's secondary schools. *NASSP Bulletin, 94*(1), 5; 5-16; 16.

Moon, N. W., Todd, R. L., Morton, D. L., & Ivey, E. (2012). Accommodating students with disabilities in science, technology, engineering, and mathematics (STEM): Findings from research and practice for middle grades through university education. Center for Assistive Technology and Enviornmental Access.

Naraian, S., & Surabian, M. (2014). New literacy studies: An alternative frame for preparing teachers to use assistive technology. *Teacher Education and Special Education*, 37(4), 330-346.

New Jersey Department of Education (2005). *Background paper: Special education, state and federal requirements and aid.* Retrieved from http://www.njleg.state.nj.us/PropertyTaxSession/OPI/specialeducation.pdf

No Child Left Behind Act of 2001, P.L. 107-110, 20 U.S.C. § 6319 (2002).

Orkwis, R., & K. McLane. (1998). A curriculum every student can use: Design principles for student access, ERIC/OSEP Topical Brief. Reston, VA: *ERIC Clearinghouse on Disabilities and Gifted Education*. Available at: www.eric.ed.gov/PDFS/ED423654.pdf.

Ozobot teacher's guide. (n.d.). Retrieved from http://files.ozobot.com/stem-education/ozobot-teachers-guide.pdf

Park, E., & Kwon, S. J. (2016). The adoption of teaching assistant robots: A technology acceptance model approach. *Program, 50*(4), 354-366. Retrieved from http://www.emeraldinsight.com/loi/prog

Pepe, C. (2016). How to use robots in elementary classrooms. *Daily Genius*. Retrieved from http://dailygenius.com/robots-classroom/

Pepe, C. (2015). *Redefining special education with dancing robots and Google Hangouts*. Retrieved from https://www.edsurge.com/news/2015-07-30-redefining-sped-inclusion-with-partnerships-robots-and-google-hangouts

Perelmutter, B., McGregor, K. K., & Gordon, K. R. (2017). Assistive technology interventions for adolescents and adults with learning disabilities: An evidence-based systematic review and meta-analysis. *Computers & education*, *114*, 139-163.

Poel, E. W., Wood, J., & Schmidt, N. (2013) Including assistive technology in teacher preparation: Exploring one approach. *Learning Disabilities.* 19(1), 29-37.

President's Council of Advisors on Science and Technology (PCAST), Executive Office of the President. (2010). *Prepare and inspire: K-12 education in science, technology, engineering, and math (stem) for America's future* (pp. 1-108). Washington, D.C. Retrieved from https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/pcast-stemed-report.pdf.

Rihar, A., Mihelj, M., Kolar, J., Pasic, J., & Munih, M. (2015). Sensory data fusion of pressure mattress and wireless inertial magnetic measurement units. *Medical and Biological Engineering and Computing*, *53*(2), 123-135. doi:10.1007/s11517-014-1217-z

Robins, B., Dautenhahn, K., Boekhorst, R. T., & Billard, A. (2005). Robotic assistants in therapy and education of children with autism: Can a small humanoid robot help encourage social interaction skills? *Universal Access in the Information Society, 4*(2), 105-120. doi:10.1007/s10209-005-0116-3

Rose, D., & Meyer, A. (2002). *Teaching every student in the digital age: Universal Design for Learning.* Alexandria, Virginia: Association for Supervision and Curriculum Development.

Sachdeva, N., Tuikka, A., Kimppa, K. K., & Suomi, R. (2015). Digital disability divide in information society. *Journal of Information, Communication & Ethics in Society*, *13*(3), 283-298. Retrieved from http://www.emeraldinsight.com/journal/jices

Scherer, M. J. (2002). The change in emphasis from people to person: Introduction to the special issue on assistive technology. *Disability & Rehabilitation*, *24*(1-3), 1-4. doi:10.1080/09638280110066262

Seale, J., Georgeson, J., Mamas, C., & Swain, J. (2015). Not the right kind of 'digital capital'? An examination of the complex relationship between students with disabilities, their technologies and higher education institutions. *Computers & Education*, *82*(1), 118-128. Retrieved from https://www.journals.elsevier.com/computers-and-education/

Shamsuddin, S., Yussof, H., Ismail, L. I., Mohamed, S., Hanapiah, F. A., & Zahari, N. I. (2012). Humanoid robot NAO interacting with autistic children of moderately impaired intelligence to augment communication skills. *Procedia Engineering, 41*, 1533-1538. doi:10.1016/j.proeng.2012.07.346

Sharkey, A. (2014). Robots and human dignity: A consideration of the effects of robot care on the dignity of older people. *Ethics and Information Technology*, *16*(1), 63-75. doi: 10.1007/s10676-014-9338-5

Smith, K., Ayres, K., Alexander, J., Ledford, J., Shepley, C., & Shepley, S. (2016). Initiation and Generalization of Self-Instructional Skills in Adolescents with Autism and Intellectual Disability. *Journal Of Autism & Developmental Disorders*, *46*(4), 1196-1209. doi:10.1007/s10803-015-2654-8

Smitha, K. G., & Vinod, A. P. (2015). Facial emotion recognition system for autistic children: A feasible study based on FPGA implementation. *Medical and Biological Engineering and Computing*, *53*(11), 1221-1229. Retrieved from http://2016.ifmbe.org

Soorenian, A. (2014). Technological aids: Key barriers and experiences of disabled international students. *Equality, Diversity and Inclusion: An International Journal*, *33*(1), 42-53. http://www.emeraldinsight.com/journal/edi

Sphero breaks the rules with new SPRK bot - Yahoo Finance. (n.d.). Retrieved from http://finance.yahoo.com/news/sphero-breaks-rules-sprk-bot-123000100.html

Sphero connected entertainment robots. (n.d.). Retrieved February 23, 2018, from http://www.sphero.com/education

Spooner, F., McKissick, B. R., & Knight, V. F. (2017). Establishing the state of affairs for evidence-based practices in students with severe disabilities. *Research and Practice for Persons with Severe Disabilities*, 42(1), 8-18. doi:10.1177/1540796916684896

Stanberry, K. (n.d.). Understanding individualized education programs. Retrieved June 17, 2017, from https://www.understood.org/en/school-learning/special-services/ieps/understanding-individualized-education-programs

Tadesse, Y., Wu, L., & Saharan, L. K. (2016). Musculoskeletal system for bio-inspired robotic systems. *Mechanical Engineering, 138*(3), S11-S16. Retrieved from https://search.proquest.com/docview/1833942539?accountid=12793

Tapus, A., Peca, A., Aly, A., Pop, C., Jisa, L., Pintea, S., David, D. O. (2012). Children with autism social engagement in interaction with nao, an imitative robot: A series of single case experiments. *Interaction Studies*, *13*(3), 315-347. doi:10.1075/is.13.3.01tap

Trainor, A. A., Morningstar, M. E., & Murray, A. (2016). Characteristics of transition planning and services for students with high-incidence disabilities. *Learning Disability Quarterly, 39*(2), 113-124.

Troccoli, A. E. (2017). *Attitudes toward accommodations and academic well-being of college students with disabilities*. Retrieved from https://rdw.rowan.edu/cgi/viewcontent.cgi?referer=&httpsredir=1&article=3411&context=etd

Tschannen‐Moran, M., Uline, C., Hoy, A. W., & Mackley, T. (2000). Creating smarter schools through collaboration. *Journal of Educational Admin, 38*(3), 247-272. 10.1108/09578230010342312

Tsui, K. M., McCann, E., McHugh, A., Medvedev, M., Yanco, H.,A., Kontak, D., & Drury, J.,L. (2014). Towards designing telepresence robot navigation for people with disabilities. *International Journal of Intelligent Computing and Cybernetics, 7*(3), 307-344. Retrieved from http://www.emeraldinsight.com/journal/ijicc

Understanding the IEP Process. *Understanding Special Education: A Parent Guide*. N.p., n.d. Web. 28 Feb. 2018. <http://www.understandingspecialeducation.com/IEP-process.html>.

van den Heuvel, R. F., Lexis, M. S., Janssens, R. L., Marti, P., & de Witte, L. P. (2017). Robots supporting play for children with physical disabilities: Exploring the potential of IROMEC. *Technology & Disability*, *29*(3), 109-120. doi:10.3233/TAD-160166

Vidacek-Hains, V., Kozina, M., & Kirinic, V. (2016). A model of education for assistants of students with disabilities supported by information and communication technology. *Economic and Social Development: Book of Proceedings, 126* (1), 4-7. Retrieved from www.esd-conference.com

Wei, X., Yu, J. W., Shattuck, P., McCracken, M., & Blackorby, J. (2013). Science, technology, engineering, and mathematics (STEM) participation among college students with an autism spectrum disorder. *Journal of autism and developmental disorders*, *43*(7), 1539-1546. Retrieved from https://link.springer.com/journal/10803

Yin, R. K. (2013). *Case study research: Design and methods*: Thousand Oaks, CA: Sage.

Yook, J., & Kim, J. (2015). The advanced korea--computer access assessment system (K-CAAS) on smart mobile cloud environment. *Multimedia Tools and Applications, 74*(16), 6197-6207. Retrieved from https://www.micc.unifi.it

Yuen, T. T., Mason, L. L., & Gomez, A. (2014). Collaborative robotics projects for adolescents with autism spectrum disorders. *Journal of Special Education Technology*, *29*(1), 51-62.

Yussof, H., Ismail, L. I., Shamsuddin, S., Hanapiah, F. A., Mohamed, S., Piah, H. A., Zahari, N.I. (2012). Human-robot interaction intervention therapy procedure for initial response of autism children with humanoid robot. Retrieved from https://asknao.aldebaran.com/sites/default/files/publications/yussofismailshamsuddin_2013_humanrobotinteractioninvterventiontherapy.pdf

Zhuhadar, L., Carson, B., Daday, J., Thrasher, E., & Nasraoui, O. (2016). Computer-assisted learning based on universal design, multimodal presentation and textual linkage. *Journal of the Knowledge Economy, 7*(2), 373-387. doi: 10.1007/s13132-016-0371-y

Appendix A. Institutional Review Board Approval

NJCU

October 26, 2017

NOTICE OF IRB REVIEW

Dr. Laura Zieger
Stephanie Talalai
Department of Educational Technology
New Jersey City University, 2039 Kennedy Blvd.
Jersey City, NJ 07305

INITIAL, REVISED OR CONTINUATION

The project identified below, for which you requested review and approval by the NJCU Institutional Review Board for the Protection of Human Participants in Research, has now been reviewed and approved. This approval is based on the assumption that the documents you submitted to the NJCU IRB contain a complete and accurate description of all the methods and processes in which human subjects are involved in your research.

As Chair of the Institutional Review Board (IRB), I have evaluated the involvement of humans as research subjects in the proposed study, entitled: **"A Case Study of the Integration of Robotics to Support the Educational and Therapeutic Goals of Students with Low Incidence Disabilities"**

In accordance with Title 45 *Code of Federal Regulations Part 46.101, b, 2,* policy guidelines from the U.S. Department of Health and Human Services, I inform you that this study is determined to be **APPROVED**.

This approval is subject to the following conditions:

1. That you will conduct the research according to the plans and protocol you submitted.
2. That you will immediately inform the IRB of any injuries to any subject that occurs during your research.
3. That you immediately inform the IRB of any problems that arise during your research.
4. That you will immediately inform the IRB of any changes that you make in the protocol of the research.
5. That you will give each person who signs the consent form a copy of that document as part of your research. The consent form must be the same one submitted with your application materials and approved by the IRB.
6. That you will retain all signed consent documents for at least three years after the termination of the research.
7. No further review and approval by the IRB are required if the study is conducted as proposed. Any proposed change in the study must be submitted to IRB Chair for further review before the proposed change can be implemented.

Failure to comply with these conditions will result in the withdrawal of this approval.

Names of the Principal Investigators: Dr. Laura Zieger and Stephanie Talalai

Title of the Project: "A Case Study of the Integration of Robotics to Support the Educational and Therapeutic Goals of Students with Low Incidence Disabilities"

Approved [**X**] Not Approved [ ]

Signed:

Ashok Vaseashta. **October 26, 2017**

NJCU IRB Chair Date

Dr. Ashok Vaseashta, Chair, NJCU IRB
Executive Director, Office of Research Grants and Sponsored Programs
2039 Kennedy Boulevard, Jersey City, NJ 07305
NJCU: The blueprint for tomorrow. http://www.njcu.edu

Appendix B. Permission from NJCU Provost

Dear Dr. Daniel J. Julius,

I am a doctoral candidate in the Educational Technology Leadership Program at New Jersey City University. I will be conducting my dissertation research under the supervision of Dr. Laura Zieger. As part of my doctoral dissertation entitled "A Case Study of the Integration of Robotics to Support the Educational and Therapeutic Goals of Students with Low-incidence Disabilities," I am requesting permission to conduct this study at the A. Harry Moore School of New Jersey City University, a school that has already been recognized for its innovative use of robotics.

The purpose of this qualitative single case study is to evaluate teacher, therapeutic and administrative knowledge, implementation and perceptions of the use of robotics for students with low-incidence disabilities in a specialized school setting. The goal is to gain an understanding of how robotics impact the educational and therapeutic goals of these students.

All classroom teachers, therapists, and school administrators will be invited to participate. Each participant will be asked to consent to a pre-interview, classroom observation, and post-interview. To preserve the confidentiality of all the participants, a coding system will be used to identify individuals. Individuals or the school district may discontinue participation in this study at any time they want.

Mr. Steve Goldberg, principal of A. Harry Moore, has given his approval to conduct this study and has agreed to have the school specifically named in the study. Additionally, it is my belief that the outcomes of this study will inform current and future teachers of students with disabilities and researchers on the educational and therapeutic benefits of robotics.

At the conclusion of the study, I would be happy to share the results with you. If you have any questions or concerns, please contact me at stalalai@njcu.edu. You may also contact my advisor, Dr. Laura Zieger, at (201) 200-3078 or lzieger@njcu.edu.
Please review and complete the section below. Thank you in advance for your consideration.

Sincerely,

Stephanie Talalai

Please indicate whether or not you will allow the A. Harry Moore School of NJCU to participate in this study by checking one of the statements below and signing.

______ I grant permission to conduct the study.

______I do not grant permission to conduct the study

______________________________________ ____________________

Provost's Signature Date

______________________________________ ____________________

Principal Investigator Date

Appendix C. Permission from NJCU Dean of the College of Education

October 27, 2017

Dear Dean Woo,

I am a doctoral candidate in the Educational Technology Leadership Program at New Jersey City University. I will be conducting my dissertation research under the supervision of Dr. Laura Zieger. As part of my doctoral dissertation entitled **"A Case Study of the Integration of Robotics to Support the Educational and Therapeutic Goals of Students with Low Incidence Disabilities,"** I am requesting permission to conduct this study at the A. Harry Moore School of New Jersey City University, a school that has already been recognized for its innovative use of robotics.

The purpose of this qualitative single case study is to evaluate teacher, therapeutic and administrative knowledge, implementation and perceptions of the use of robotics for students with low-incidence disabilities in an inclusive school setting. The goal is to gain an understanding of how robotics impact the educational and therapeutic goals of these students.

All classroom teachers, therapists and school administrators will be invited to participate. Each participant will be asked to consent to a pre-interview, classroom observation and post-interview. To preserve the confidentiality of all the participants, a coding system will be used to identify individuals. Individuals or the school district may discontinue participation in this study at any time.

Mr. Steve Goldberg, principal of A. Harry Moore, has given his approval to conduct this study and has agreed to have the school specifically named in the study. Additionally, it is my belief that the outcomes of this study will inform current and future teachers of students with disabilities and researchers on the educational and therapeutic benefits of robotics.

At the conclusion of the study, the results will be made available you. If you have any questions or concerns, please contact me at stalalai@njcu.edu . You may also contact my advisor, Dr. Laura Zieger, at (201) 200-3078 or lzieger@njcu.edu.
Please review and complete the section below. Thank you in advance for your consideration.

Sincerely,

Stephanie Talalai

Please indicate whether you will allow the A. Harry Moore School of NJCU to participate in this study by checking one of the statements below and signing.

__✓__ I grant permission to conduct the study.

______I do not grant permission to conduct the study

Deborah Woo (signature) 10/27/17
Dean's Signature Date

Stephanie Talalai
Principal Investigator Date

Appendix D. Permission from A. Harry Moore

October 26, 2017

Dear Mr. Goldberg:

I am a doctoral candidate in the Educational Technology Leadership Program at New Jersey City University. I will be conducting a study entitled "A Case Study of the Integration of Robotics to Support the Educational and Therapeutic Goals of Students with Low Incidence Disabilities," under the supervision of Dr. Laura Zieger as part of my doctoral dissertation concerning the educational and therapeutic benefits of using robotics with students with low incidence disabilities. I am requesting to conduct this study at the A. Harry Moore School. The goal of the study is to evaluate teacher, therapeutic and administrative knowledge, implementation and perceptions of the use of robotics for students with low-incidence disabilities in an inclusive school setting to gain an understanding of how they impact their educational and therapeutic goals.

All classroom teachers, therapists and school administrators will be invited to participate. Each participant will be asked to consent to a pre-interview, classroom observation and post-interview. To preserve the confidentiality of all of the participants, a coding system will be used to identify individuals. Individuals or the school district may discontinue participation in this study at any time they want.

At the conclusion of the study, results will be made available to you. If you have any questions or concerns please contact me at 201-200-3208 or stalalai@njcu.edu. You may also contact my advisor, Dr. Laura Zieger, at 201-200-3420 or lzieger@njcu.edu or Dr. Ashok Vaseashta, Chair of NJCU Institutional Review Board, at 201-200-2453 or avaseashta@njcu.edu.

Sincerely,

Stephanie Talalai

Please indicate whether or not you will allow your school to participate in this study by checking one of the statements below and signing.

✓ I grant permission to conduct the study.

_____ I do not grant permission to conduct the study

____________________ 10/27/2017

Lead Administrator's Signature — Date

Stephanie Talalai

Signature of Principal Investigator — Date

Appendix E. Informed Consent Form Teacher/Therapist

I agree to participate in a study entitled "A Case Study of the Integration of Robotics to Support the Educational and Therapeutic Goals of Students with Low-incidence Disabilities," which is being conducted by Stephanie Talalai, a doctoral candidate in the Educational Technology Department at New Jersey City University. The purpose of this study is to evaluate teacher, therapeutic and administrative knowledge, implementation and perceptions of the use of robotics for students with low-incidence disabilities in an specialized school setting to gain an understanding of how they impact their educational and therapeutic goals. I understand that the data collected in this study will be combined with data from previous studies and will be submitted for publication in partial satisfaction of the requirement for the degree of Doctor of Educational Technology Leadership.

I understand that I will be required to participate in both pre-and post-interviews and I will be observed using robotics within my classroom/therapeutic setting. I also understand that my interview responses will be recorded. My participation in the study should not exceed two hours.

I understand that my responses will be anonymous and that all the data gathered will be confidential. I agree that any information obtained from this study may be used in any way thought best for a doctoral dissertation publication provided that I am in no way identified and my name is not used.

I understand that there are no physical or psychological risks involved in this study and that I am free to withdraw my participation at any time without penalty.

I understand that my participation does not imply employment with the state of New Jersey, New Jersey City University, the principal investigator, or any other project facilitator.

If I have any questions or problems concerning my participation in this study I may contact Dr. Laura Zieger at 201-200-3078 or Dr. Ashok Vaseashta, Chair of NJCU Institutional Review Board, at 201-200-2453 or email avaseashta@njcu.edu.

Signature of Participant | Date

Stephanie Talalai

Signature of Principal Investigator | Date

Appendix F. Parental Informational Letter

Dear Parents/ Guardians,

My name is Stephanie Talalai and I am a doctoral candidate in the Educational Technology Leadership Program at New Jersey City University. I am conducting a research study at the A. Harry Moore School entitled "A Case Study of the Integration of Robotics to Support the Educational and Therapeutic Goals of Students with Low-incidence Disabilities." This study will evaluate teacher, therapeutic and administrative knowledge, implementation and perceptions of the use of robotics for students with low-incidence disabilities in a specialized school setting. Its purpose is to gain an understanding of how robotics impact student educational and therapeutic goals.

I may be in your child's classroom and/or therapy session once during the study. While I'm in the classroom, I will observe the teacher's instructional methods and take notes. I will not record your child's name or any other materials that will identify your child. Your child will not do anything outside of his/her normal classroom activities, and there is no risk to your child.

If you have any questions or concerns about the study, or if you would like to withdraw your child from the study, please contact myself or A. Harry Moore principal, Steve Goldberg:

Stephanie Talalai
stalalai@njcu.edu or 201-200-3208

Steve Goldberg
sgoldberg@njcu.edu or 201-200-3138

If you have questions about your rights as a research participant, please contact:
Dr. Ashok Vaseashta,
Chair of NJCU Institutional Review Board
Telephone: 201-200-2453
Email: avaseashta@njcu.edu

Sincerely,

Stephanie Talalai

Stephanie Talalai

Appendix G. Pre-Observation Interview Protocol

Interviewee: ____

Time of Interview: __________________________ Date: ___________________________

Recording/Storing information about interview: _________________________________

Introduction

- Explain study to interviewee.
- Explain researcher's role as an observer and that the interviewee is viewed as an expert.
- Address any questions about the study.
- Explain confidentiality.
- Obtain permission to record interview.
- Ask if there are any questions about the process.
- Review UDL Guidelines

Interviewee Background

1. How many years have you been teaching or providing therapeutic services for students with low-incidence disabilities?
2. How many of those years have been at A. Harry Moore?

Implementation

3. Tell me about your background in implementing robotics into your lessons/ therapy sessions.
4. Describe the professional development you received for implementing robotics within your lessons/ therapy sessions.
5. Tell me your thoughts and opinions on implementing robotics into your lessons/ therapy sessions.
6. Do you feel that you receive enough support for successful implementation? Why or why not?
7. What are your student(s) educational or therapeutic objective for implementing robotics in your lesson/ therapy session?
8. How often do you integrate robotics into your lessons? Daily, weekly?

9. Since implementing robotics, have you seen an increase in educational/ therapeutic goal achievement? Explain or give examples.
10. What subject/ therapeutic intervention will be observed and what robots will be utilized?
11. What are the educational or therapeutic goals and objectives of the lesson?
12. What UDL principles most closely align with your goal for this lesson/ therapeutic session?
13. Please describe what activity will be completed with the use of robotics and how it was chosen.
14. Is there anything you would like to share about the program or the lesson I will observe?

Appendix H. Teacher/ Therapist Observational Protocol

<table>
<tr><td>Date:</td><td colspan="2">Teacher/Therapist:</td></tr>
<tr><td>Student(s) Age:</td><td colspan="2">Number of Students:</td></tr>
<tr><td>Observation Start Time:</td><td>End Time:</td><td>Subject:</td></tr>
<tr><td colspan="3">Lesson Topic:</td></tr>
<tr><td colspan="3">Robotics used by Teacher/Student(s):</td></tr>
<tr><td colspan="2">Descriptive Notes:</td><td>Reflective Notes: [Reflective comments: questions to self, observations of nonverbal behavior, my interpretations]</td></tr>
</table>

Physical Setting: Description of Activity: UDL Guidelines Used: Educational/Therapeutic Goals:	

Appendix I. Post Observation Interview Protocol

Interviewee: ____

Time of Interview: __________________________ Date: ___________________________

Recording/Storing information about interview: _________________________________

- Explain that the post observation interview will focus on observation data.
- Researcher will give a summary of observation and ask if there is anything in the summary that should be clarified, added, or changed.

Lesson

1. What was your educational/ therapeutic goal for this lesson/session?
2. How did you plan for this lesson?
3. How do you feel the students received this lesson? Did it go as planned?
4. What would you change about the lesson the next time it is presented to the students? Why?
5. Has this lesson been taught previously without the use of robotics? If so, did you see a difference?
6. Do you find value in the use of robotics with your students? Why or why not?
7. How long have your students been working with robotics?
8. Please explain how you measure engagement and goal achievement with your students.
9. Do you feel that the use of robotics during lessons increases engagement and goal achievement with your students? Why or why not?
10. What do you feel are the constraints that affect the implementation of robotics in your classroom? Why?
11. What are the factors that influence the use of robotics in your classroom?
12. Is there anything else you would like to share about the lesson?

Appendix J. Administrator Interview Protocol

Interviewee: ____

Time of Interview: __________________________ Date: ___________________________

Recording/Storing information about interview: _________________________________

Introduction

- Explain study to interviewee.
- Explain researcher's role as an observer and that the interviewee is viewed as an expert.
- Address any questions about the study.
- Explain confidentiality.
- Obtain permission to record interview.
- Ask if there are any questions about the process.

Questions

1. What was your vision for technology integration at A. Harry Moore, especially with the introduction of robotics?
2. Do you feel robotics integration is important for improving the educational and therapeutic goals of students at A. Harry Moore? Why?
3. Explain the decision-making process for technology/ robotics integration.
4. What budgetary considerations are made before technology/ robotics purchasing?
5. What can an administrator do to influence the use of technology/ robotics for instructional purposes in the classroom?
6. Once the student and teacher/ therapeutic needs are determined, how do you prioritize and address the needs?
7. Describe your involvement in designing the school-based professional development plan and the delivery of the professional development for technology/ robotic implementation.
8. What types of training does A. Harry Moore provide for integrating robotics for instructional purposes?
9. How do you inspire teachers/ therapists in the use of technology/ robotics for instruction in the classroom?
10. What obstacles do teachers/ therapists encounter in instructional technology use in the classroom?