Using Robots to Teach Autistic Students

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**Overview and Rationale**

**Autism**

Autism spectrum disorder is a developmental disability that can impact individuals’ social, emotional, and communication skills. American Centers for Disease Control and Prevention estimates the prevalence rate of autism to be approximately 1 in 68 births (Christensen et al., 2016). People with autism have a broad range of cognitive abilities ranging from high-functioning to severely challenged. Autistic students often have different ways of learning, focusing, and reacting to stimuli (Giullian et al., 2010). This proposal will focus on how robots can help meet the unique educational needs of autistic students.

**Robots**

Robots are programmable machines capable of automatically executing actions through an external or internal control mechanism. They can be autonomous or semiautonomous and respond to external stimuli through the use of sensors and actuators (Boser et al., 2014; Boucenna et al., 2014). Humanoid robots are constructed to replicate a human form and mimic human actions.

**Robots for Autism Education**

Research has revealed the motivational benefit and educational potential of using robots in the classroom (Boser et al., 2014; Boucenna et al., 2014; Goulart et al., 2014). Children with ASD tend to engage for longer periods with robots over humans (Boser et al., 2014; Diehl et al., 2012). The development of specialized robots for autism therapy and education creates a unique opportunity to differentiate and individualize the learning experience for autistic students in the classroom.

Boser et al. (2014) identified four areas where students benefit from robot interventions; cueing and joint attention, social skills learning, language and communication, and motor skills learning. Research has repeatedly shown students with ASD typically prefer spending time with, and paying attention to, robots over people (Boser et al., 2014; Diehl et al., 2012). Hyperarousal is a common response of ASD children when facing human-to-human interactions (Goodwin et al., 2006). As a result, ASD children prefer not to interact with others, or, if they are forced to interact, then they will not fully engage due to their hyperarousal. Unfortunately, this delays their learning and acquisition of crucial joint attention and social skills. Studies have shown robots decrease the ASD hyperarousal reaction and create a calming effect (Boser et al., 2014; Duquette et al., 2007). Robots can also reduce ASD children’s inhibitions to engage in imitation behaviors for learning motor skills through robot-human imitation exercises (Boser et al., 2014; Hill, 2004). Therefore, robots programmed to mimic human interaction have been successfully implemented in therapeutic and educational settings, facilitating the learning of joint attention, social skills, motor skills, and language and communication skills at a younger age.

Gillesen et al. (2011) describe learning objectives for language and social skills, a crucial area for ASD learners, that have been successfully addressed by robot interventions. The authors explain several robot-child interaction scenarios promoting imitation, joint attention, and turn-taking. These exercises set the foundation for higher level robot-child learning exercises including responding to the robot’s request for assistance (Gillesen et al., 2011). This in-turn prepares the child for higher level exercises such as responding to the robot’s request for assistance in problem solving. As the child strengthens their skills in these foundational areas, they can move on to taking the lead role in conversation by asking the robot questions and maintaining a simple dialogue about various topics (Gillensen et al., 2011).

**Meeting ASD Learner Needs with Robots**

 Robots are programmable and adjustable to the individual needs and proficiency level of the student. The flexibility of robots as a learning tool is one of the features that make them such a remarkably effective classroom intervention (Boser et al., 2014; Boucenna et al., 2014; Goulart et al., 2014). They benefit ASD students by providing multiple means of learning, reinforcement, expression, assessment, and motivation. They provide an opportunity for learners to gain knowledge and reinforce what they’ve learned through a variety of methods. Robot technology also allows ASD children to demonstrate what they have learned in a variety of ways while providing the educator with multiple means to assess learning. Finally, with the growing trend of autistic employees in Silicon Valley, we have witnessed how technology, including robotics, can motivate and spark the intellectual curiosity of autistic children to ultimately shape their career goals.

**Program Evaluation**

 New Jersey Department of Education (2004) presents the following seven quality indicators for implementation and evaluation of educational programs for autistic students; “program characteristics, personnel, curriculum, methods, family involvement and support, community collaboration and program evaluation” (New Jersey Department of Education, 2004). This section will focus on describing how to maintain quality curriculum and instructional methods, and rigorous program evaluation for a robotics-based educational program for students with ASD.

**Maintaining a Quality Curriculum and Instructional Methods**

 The program curriculum and instructional methods are grounded in thoroughly researched and validated practices that have proven successful in autistic educational settings. A primary goal of the curriculum and instructional methods is to maximize students’ independence in and outside of school. The curriculum emphasizes development of eight crucial areas for the autistic child; communication and language, social skills, play, imagination, creativity, engagement, academics, challenging behaviors, and self-management. The program will employ effective instructional techniques using robots to help children learn communication and language. Robots will be used to facilitate the development of social skills and reinforce play, imagination, and creativity. The program will also develop student engagement through robot-human interaction exercises.

 The instructional approach will be based upon research-backed methods that promote the development of targeted skills. New Jersey Department of Education (2004) includes the following checklist for quality instructional methods in an educational program for autistic children.

1. “Emphasize the use of naturally occurring reinforcers (rewards)” (New Jersey Department of Education, 2004)
2. Recognize, and reinforce successful outcomes
3. Promote communicating and socializing
4. Promote the application of learned skills in various settings and situations

Generalization and maintenance of acquired skills will be systematically promoted in a variety of contexts so as to maximize students’ ability to function in natural environments. Instructional methods will be differentiated and individualized to meet the specific needs and abilities of each student. The effectiveness of instructional methods will be systematically documented.

**Measures of Program Effectiveness**

An evaluation system will be implemented to assess whether the robotics program meets expectations in several areas. An important measure of program success includes student progress towards mastery of IEP goals (New Jersey Department of Education, 2004). This data is collected and analyzed individually for each student. Data on State and district-wide benchmark tests are also collected and analyzed to determine student academic progress. Student progress on generalization of acquired skills is another aspect that will be measured to determine program success. Finally, student achievements and progress toward independence and self-management will also serve as a measure of program effectiveness. Observation and evaluation of the program by an external expert in autism teaching practices will be conducted on an annual basis. Parents will also be asked to evaluate the program on an annual survey tool. Parent feedback, student results, and staff input will be compiled and analyzed to contribute towards program evaluation and improvement.

 The quality of the robot-based curriculum will be assessed using a rubric adapted from Maine’s curriculum evaluation tool (see Appendix A). The evaluation assesses seven broad quality indicators. It begins with determining whether appropriate processes and tools are being utilized to determine student interests and learning styles, and whether that information is used to inform learning and instruction. The evaluation tool also assesses whether the appropriate processes and tools are being utilized to assess student prior knowledge. Alignment with appropriate educational content standards is checked, along with the clarity of anticipated learning outcomes. The instructional strategies component of the rubric determines whether the curriculum is learner-centered, flexible, multi-sensory, research-based, and makes effective use of technology. The assessment component of the rubric evaluates the quality of student evaluations, and whether results from the evaluations are used to inform instruction. Finally, the quality of instructional resources is checked to determine relevancy and age/skill-appropriateness.

**Nationwide Initiative**

The Individuals with Disabilities Education Act (IDEA) was implemented to ensure that all children with disabilities are entitled to a free appropriate public education in order to meet their unique, individualized needs and prepare each for further education, employment, and independent living (2004). Advances in technology, along with an increase in understanding of effective teaching strategies for meeting the needs of autistic learners, provides an opportunity for more individualized instruction. Combining this with a more systematic approach toward improvements in the way that data is obtained, evaluated, and used to inform decisions, provides an opportunity to focus interventions through socially adaptive/assistive robots which are transformable, adaptable, and modifiable to better meet program goals and individual learner needs.

Autism is a pervasive developmental disorder that is characterized by social and communicative impairments. Social robots recognize and respond to human social cues with appropriate behaviors. Based on three years of integration and immersion with a clinical research group, studies show how social robots will make an impact on the ways in which we diagnose, treat, and understand autism (Scassellati, 2007). Socially Assistive Robotics applications is a developing field of study that utilizes robotics to address the individualized needs of students on the autism spectrum. The study of human-robot interaction (HRI) for socially assistive robotics applications is a developing field of research that merges a broad spectrum of research areas to include; robotics, medicine, social and cognitive sciences, and neuroscience (Tapus, 2007). Considering the research into these areas will give a broader understanding of how to utilize robotics technology to meet the of students on the Autism spectrum.

Technology continues to evolve at a rapid rate. It would be detrimental and self-defeating to implement a fixed program based on current technology trends. Technological changes can often relegate the latest technologies into a passing fad. With this in mind, it is important to develop adaptable programs that incorporate all available and effective technologies and take into consideration the inevitable adaptations and generational improvements to a given technology. Possible inclusions within an SAR may include use of audio and video recorders, electronic sensing technology, computer architecture, hardware, and software; virtual reality, and the field of robotics. These technologies can be utilized in conjunction with each other and be beneficial in developing individualized education plans. In addition to the immense benefit to individuals with autism are the benefits to their families, and the practitioners who support them (Goodwin, 2008). The University of Southern California conducted a study where researchers examined how children with ASD react to humanoid robots that provide graded cueing, an occupational therapy technique that shapes behavior by providing increasingly specific cues, or prompts, to help a person learn new or lost skills (USC, 2014). Additional research suggests that informed strategies in the field of socially assistive robots may be beneficial for children and lay a foundation for an argument that training and practice of child therapy should viewed through b developmental and a psychodynamic lens (Kuhn 2015). This research supports the development of a robotics program based on adaptable robots to develop learner skills.

Assistive robotics, in general, and socially assistive robotics in particular, have the potential to enhance the quality of life for a broad population of users: the elderly, individuals with physical impairments and those in rehabilitation therapy, and individuals with cognitive disabilities and developmental and social disorders (Tapus 2007). This idea may be applicable to students with Autism by enhancing their learning opportunities and providing them with a tool that can be adapted to each individual’s needs. The range of options for developing a SAR system for Autistic students is enormous, and studies have shown that these issues are without a consensus as to a single optimal design (Scassellati et, al. 2012). When considering the vast amounts of technology and the speed with which technology is advancing, it is highly recommended that any robotics intervention programs be designed and developed with an adaptable mindset. Meaning, the technology needs to be built to be expandable and adaptable to changes in technology itself, as well as to changes in pedagogical understanding, and in consideration of individual learner needs. This will also help alleviate some of the costs of having to revamp or change an entire system when technology advances and learner’s needs change. In consideration of these findings, socially assistive robotics programs should be developed to allow for change and adaptability and better meet the needs of learners with autism.

When considering Socially Assistive/adaptive robotics for autism. It is essential to keep in mind that each student is at a different level of progression within an autism spectrum. Scasellati (2012) says that the field contains numerous studies with different methods and goals, but that basically, the studies can be broken down into three general categories that are connected yet discreet. The key components of a good plan include physical robot design which includes:

1.) The physical consideration of robot design for individual users and focuses on appearance and functionality of the robot. Consideration is how anthropomorphic the robot should appear to the learner.

2.) Human-Robot Interaction. The responses and stimuli the robot will respond to will be based on individual learner needs.

3.) Evaluation of robots in therapy-like settings. The interaction between learner/robot will be studied both qualitatively and quantitatively to determine effectiveness.

Since each student varies in response to stimuli, it will be incumbent for those developing a learner’s education plan to assess student needs and modify the robot’s functionality to best meet that student’s learning needs and the overall program goal. It will be important to conduct mixed method research to collect both quantitative and qualitative data for determining program effectiveness. This data will be utilized to evaluate individual program success based on student learning objective and goal attainment. Data will also be collected per school, district, and on a nationwide basis to conduct further analysis of overall program success. Data will be analyzed and used to drive program decisions.

**Reflection**

 At the conclusion of the semester we saw how far we had come in integrating technology in Early Childhood learning with Blocks to Robots: Learning with Technology (Bers, 2008). Here we saw a practical application of how robots can be used for playful learning to help those with disabilities, including an Autism Spectrum Disorder. In this reading the author suggests that robots while used in childhood can help with fine motor skills, coordination, social skills, an enfacement in communication ability and an expansion of pretend play. Examples of robots in the classroom that are introduced are robots such as LEGO Mindstorms.

Looking back over the course of this semester we have examined several areas that we can reflect on when applying technology of teaching autistic students in the classroom with robots. Early in the course we looked at the Evolution of Instruction in Technology Rich Classroom (Sandholtz, 1997). Looking at NAO we would see how far the discipline has evolved and the opportunities that lie ahead with this application of a truly student centered classroom. From Universal Design for Learning (UDL) Guidelines Version 2.0 (CAST, 2011) we see UDL and its three principals of representation, action, expression, and engagement are all enhanced through the usage of technology for the special needs learner. Robots helping children with autism is part of the evolution of UDL. For many years educators were often tied down to a ‘one-size-fits-all’ curriculum and now educators have more and more opportunities to think outside of the box to help their students. It’s the principles of UDL that make technology so powerful to providing a desirable outcome for a student with a disability.

Another major lens to apply to Teaching with Robots for students with ASD is the SAMR model (Hamilton, 2016). Puenedura’s model of enhancement and transformation requires a deeper understanding of the ways technology can use Robots to enhance teaching and transform learning (Hennessey et al., 2005) and understanding the possibilities of this technology to promote student learning and achievement (Lei et al., 2008) for a disabled student.

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Appendix A

Quality Curriculum Evaluation Rubric (Retrieved on May 1, 2017 from: https://www.maine.gov/doe/adulted/admin/curriculum/quality-rubric.pdf)

