

**Emerging Technologies Supporting  
Cognitive Development In School-Age Children**

*A Master's Thesis*

*Presented to*

*Information Design and Technology*

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*In Partial Fulfillment  
of the Requirements for the  
Master of Science Degree*

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## **Abstract**

Over the past few years, the importance of mental health has gained unprecedented attention and priority across various sectors of society. Many children have dealt with some form of undiagnosed or untreated mental illness that interferes with their ability to learn. These disorders can seriously affect daily life and continue into adulthood, creating a precarious home, school, and social life.

Due to the increased use of technology over the 2020 Covid-19 pandemic, it is now commonplace to rely on technological innovations for mental health in children. Technology has advanced to expand child engagement and interactivity, especially for children who struggle with emotional regulation, social skills, and coping strategies.

Research has shown that the human brain is fully developed at age 25. The longer a child has cognitive and emotional stability, the greater it positively affects their lives. Interventions should be given early in the child's life. And if technology is available to aid in those interventions, everyone should be able to access them. The main objective of this paper is to explore how emerging digital interventions can improve mental health in children, specifically those with deficits in cognitive development. In conjunction with this paper, the website [childmindtechnologies.com](http://childmindtechnologies.com) has been created for practitioners, educators, and parents, aiming to facilitate the adoption of these digital interventions in various settings, whether it be at home, in school, or in clinical environments.

*Keywords:* special education, cognitive development, mental health, children, school-age, disorders, ADHD, social skills, Autism, emerging technology, AI, robots, video games, game-based therapeutics

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## **I. Historical Perspectives on Technology Applications**

Technology plays a crucial role in all areas of special education. Throughout the decades, we have learned many lessons on how technology can benefit a school-age child with disabilities. For this paper, I will briefly overview the history of technology applications that apply to cognitive development in school-age children.

In the mid-1960s, a new perspective on technology emerged that focused on applications versus the hardware used for interventions. This concept was coined as ‘instructional technology’ due to its role in instruction, not just the hardware. In 1970, “A Congressional Commission on Instructional Technology concluded that, in addition to devices and equipment, instructional technology also involves a systematic way of designing and delivering instruction” (Boone, 2005, p. 7).

With the development of the microcomputer in the 1970s—a compact, user-friendly computer designed for individual use—numerous applications have been created to support individuals with cognitive disabilities. Computer-assisted and multimedia instruction, assistive and adaptive equipment, and text-to-speech capabilities are a few. Since the 1980s, we've seen technology skyrocket exponentially, completely overhauling virtually every facet of our daily lives and how we communicate. We have experienced increased levels of efficiency, interconnectivity, and information access like never before. However, it is important to note that it is not just the device that is beneficial, but the application or software applied to the technology that will ultimately change the life of a child with cognitive disabilities (Boone, 2005, p. 7).

During the mid-1990s, there was a noticeable gap in comprehension regarding the technological resources accessible to households and the ways in which they could leverage

these tools for their benefit. Most families knew their children used a computer in school but not specifically what they used it for. “Although a wide array of assistive devices were used by students with intellectual disabilities, the most striking finding was that in four of the five use-specific areas, the percentage of students who could potentially benefit from assistive devices was greater than the percentage of students who currently used such devices” (Boone, 2005, p. 310). Many barriers to computer use exist, but the most important from a family perspective are lack of funds, lack of knowledge of the benefits for the family member, and lack of professional development of key interventionist providers (Boone, 2005, p. 310-311).

Many experts in cognitive development and technology can not deny the importance and transformative aspects technology presents to school-aged children and those with special needs. Even today, there are numerous deficits in access and knowledge for parents, educators and medical professionals.

## **II. Literature Review: Emerging Technologies of the 21st Century**

### ***A. Game-Based Digital Therapeutics In Children with ADHD***

#### *Attention-Deficit Hyperactivity Disorder*

“ADHD is one of the most common neurodevelopmental conditions affecting children, with an estimated 6.1 million youth aged 2–17 years (9.4%) in the United States ever having received this diagnosis” (Gallen et al., 2021). A diagnosis of Attention-Deficit Hyperactivity Disorder (ADHD) is made when there is a continuous display of lack of attention, excessive activity, and impulsive behavior. As stated in the DSM-5, the Diagnostic and Statistical Manual of Mental Disorders (American Psychiatric Association, 2013), inattention refers to failing to

give close attention to details, making careless mistakes, having trouble organizing tasks and activities, losing things necessary for tasks and activities, and being forgetful in daily activities (Antshel et al., 2011). Hyperactivity and impulsivity are seen in children who fidget, tap, or squirm in their seat, are “on the go,” act as if “driven by a motor”, and interrupt or intrude on others. It is also important to note that these behaviors, such as emotional dysregulation, depression, and attention control, can also be seen in other disorders, such as autism, bipolar, and many other mood and anxiety disorders.

“The current recommended treatments for ADHD include pharmacological and behavioral therapies. Although these treatments show some promise at ameliorating ADHD symptoms, they also have several limitations” (Gallen et al., 2021). These limitations include the adverse effects of stimulant medications, parental hesitation to explore numerous pharmaceutical options, and the lack of clinicians with the expertise to narrow down behaviors to a specific disorder. This lack of training of clinicians leads to guesswork and over-medicating children. In addition to these limitations, “engagement issues and the limited consideration of individual differences in the learning process are reported to limit the effective delivery of mental health interventions” (Choi et al., 2022).

### *Digital Therapeutics*

Digital therapeutics (DTx) is defined as “software-driven therapeutic interventions that aim to prevent, manage, or treat medical or chronic diseases” (Choi et al., 2022). The benefit of DTx, such as video game-based therapy, is the ability to personalize the treatment and intervention that can not be done with medications and traditional therapies. Furthermore, DTx does not have the adverse effects of medication and the stigma that often is carried with it. These



alternative digital therapeutics “target a key neural marker of attention – midline frontal theta (MFT) – yield positive effects on attentional control in several populations” (Gallen et al., 2021). Video game-based therapeutic approaches incorporate multitasking to allow children to practice differentiating between different patterns, colors and other stimuli the brain receives. “Based on the psychological characteristics of pediatric patients, digital therapy combined attention training techniques and neurobehavioral therapy for developmental disorders and is more adaptable for ADHD children to improve their psychosocial skills and neurocognitive functions” (He et al., 2023).

### *Video Gameplay*

Why has video gameplay received such a bad reputation? Is it the long periods of gameplay with no social interaction? Considering the history of negative perceptions, it is understandable why parents would question the validity of a prescription video game. The American Psychiatric Association and the World Health Organization have even stated that classifying video game play as a disorder should be explored in the future. Yet there are many gaps in the research on the negative effects of video games. “Nearly all non-experimental studies examining the links between video games and mental health rely on subjective, self-reported estimates of video play time, either by players themselves or by parents” (Johannes et al., 2021).

In contrast, studies show how video games can improve mental health. For example, the Royal Society Open Science published an article in 2021 called “Video game play is positively correlated with well-being,” published by researchers at the UK’s University of Oxford who claimed video game play was positively correlated with mental health (Johannes et al., 2021).

## *EndeavorRx*

EndeavorRx, a prescription game targeting attention issues in children 8-12, is the exception to the negative views video games have. Looking closer at EndeavorRx, the recommended treatment is 25 minutes daily, 5 days a week, for 4 consecutive weeks. The treatment is strongly suggested to include therapeutic programs that may include therapy, medication, and educational support.

In June 2020, the Food and Drug Administration (FDA) approved EndeavorRx as the first game-based digital therapeutic to be marketed in the U.S. “The EndeavorRx device offers a non-drug option for improving symptoms associated with ADHD in children and is an important example of the growing field of digital therapy and digital therapeutics,” said Jeffrey Shuren, M.D., J.D., director of the FDA’s Center for Devices and Radiological Health. “The FDA is committed to providing regulatory pathways that enable patients timely access to safe and effective innovative digital therapeutics” (Commissioner, 2020).

The parent company, Akili Interactive, has performed multiple studies. These studies evaluated the results of measurements of the Test of Variables of Attention (TOVA), academic performance tests, and numerous other assessment tools. According to the FDA press release, no serious adverse effects were reported (Commissioner, 2020).

We must look at how EndeavorRx differs from the common video games on the market. EndeavorRx is specifically designed to support attention control when creating the game. EndeavorRx uses sensory stimuli and motor challenges to target areas of the brain that play a key role in attention function. Patients are challenged to multitask and ignore distractions by navigating courses, collecting targets, and avoiding obstacles, and frustration tolerance is

examined as the child plays the missions. In addition, “there is no way to "win" EndeavorRx. The game continuously challenges the child by adjusting the gameplay to maintain a consistent level of difficulty relative to how well they are playing the game. As long as the child is playing consistently and trying their best, the child is engaging with the treatment as intended” (ADHD Treatment For Kids | Digital Therapeutic Video Game for ADHD, n.d.).

Akili Interactive’s “products leverage the fun, deep engagement, and rewards that make games incredibly compelling but, unlike typical video games, this personalized gameplay experience is engineered with adaptive algorithms designed to improve cognitive function” (Akili Interactive, n.d.). EndeavorRx employs various innovative technologies to provide personalized experiences that engage both the body and the brain.

1. Selective Stimulus Management Engine (SSME™): This technology provides specific types of sensory input and motor challenges to engage the brain actively. It adjusts in real-time to suit the individual’s capabilities and needs.
2. Body Brain Trainer (BBT™): BBT™ integrates cognitive tasks with physical activities within an interactive setting. The game adapts continuously, guiding users to balance physical exertion (measured by target heart rate) and cognitive challenge.
3. Spatial Navigation (SNAV™) Engine: SNAV™ focuses on improving spatial awareness and navigation skills. It does so by integrating various types of information related to time, objects, and scenes (Akili Interactive, n.d.).

### *Research*

In regards to EndeavorRx’s research, positive results have been reported. In March 2021, STARS-ADHD (The Software Treatment for Actively Reducing Severity of ADHD), a

multicenter, open-label effectiveness study of AKL-T01 (EndeavorRx's clinical name), concluded that 68% of parents reported improvements in ADHD-related impairments after two months of treatment (Kollins et al., 2021). In this study, children 8-12 years of age on stimulant medication (n = 130) or not on any ADHD medication (n = 76) were tested for attention control. This trial began with 4 weeks of gameplay, a 4-week break off the game, and then an additional 4 weeks of playing. Testing for effectiveness was performed using the Impairment Rating Scale (IRS), ADHD Rating Scale (ADHD-RS), and Clinical Global Impressions Scale-Improvement (CGI-I). Both cohorts significantly improved the IRS scale (On Stimulants: -0.7,  $p < 0.001$ ; No Stimulants: -0.5,  $p < 0.001$ ). After the first 4 weeks, the results remained stable and improved again during the second 4-week period. Although Akili funded this study, the results were published and opined by the researchers without influence from the sponsor of the research (Kollins et al., 2021).

In December 2021, an open-label EEG study in children with ADHD was published to further support digital therapeutics that target neural markers for attention control. This study examined the targeted approach that differs from typical video games today. Using electroencephalography (EEG), a test that detects abnormalities in your brain waves or the electrical activity of your brain, the first set of results showed an increase in midline frontal theta (MFT), a specific pattern of brain activity that has been linked to cognitive processes such as attention, memory, and problem-solving. Abnormalities in this pattern of activity can be associated with various neurological and psychiatric conditions (Gallen et al., 2021).

A second method of testing measured the behavioral improvements in attention. Researchers used two computerized tasks:

1. Perceptual discrimination task: a cognitive task in which participants are asked to distinguish between stimuli based on one or more of their sensory attributes.
2. Sustained attention task: a task designed to measure a person's ability to maintain focus and remain alert over a period of time (Gallen et al., 2021).

The third assessment is a parent survey called the Vanderbilt ADHD Diagnostic Parent Scale (VADPRS). The VADPRS is a 55-item parent-report assessment for ADHD (18 items), ODD (8 items), CD (14 items), and anxiety/depression (7 items). It also includes an eight-item school performance and social functioning subscale (Anderson et al., 2022). The results were positive, with parents observing a significantly lower presentation of ADHD symptoms.

All three outcome metrics supported previous testing and sparked a greater interest in future work. “The present findings demonstrate that a targeted, digital therapeutic (AKL-T01) can have wide-ranging positive effects on several metrics of attention in a heterogenous population of children with ADHD. Specifically, our primary analyses show that AKL-T01 enhances midline frontal theta (MFT), a well-established EEG-based measure of attentional control. Further, our exploratory analyses demonstrate that AKL-T01 improves performance on computerized tasks of attention as well as clinical ADHD symptoms from parent reports” (Gallen et al., 2021).

In November 2022, a systematic review of numerous video games, including EndeavorRx, was analyzed to determine the sustainability of the therapeutic effects of DTx and the transfer of cognitive functioning. Seven game-based DTx for this age group were identified through a literature search (Choi et al., 2022).

1. EndeavorRx – attention
2. ATENTIVmynd – attention
3. RECOGNeyes – attention
4. RETHink – emotion regulation
5. Mightier – emotion regulation
6. MindLight – anxiety
7. SPARX – depression

“Based on the review of literatures for the seven game-based DTx, it is found that using VGs as a delivery tool for treatment or prevention interventions in children and adolescents have the potential for therapeutic effects on targeted mental health problems (i.e., attention deficit, anxiety symptoms, emotion regulation and depression)” (Choi et al., 2022). Improvements in spatial working memory, the ability to keep spatial information active in working memory (van Asselen et al., 2006), and inhibition, the process of restraining one's impulses or behavior (APA Dictionary of Psychology, n.d.) was seen in EndeavorRx, ATENTIVmynd, and RETHink. Also seen in these three were an increased MFT power and a reorganized functional network. This study showed that game-based DTx is becoming a crucial tool used in improving the lives of children with ADHD and conditions of Autism Spectrum Disorder (ASD) and Sensory Processing Disorder (SPD). ASD and SPD need to be further researched.

### *Conclusion*

This review has supported the positive effects of game-based digital therapeutics on children's mental health. Improvements can be seen in attention, emotional regulation, frustration tolerance, and executive function. Early intervention can lead to improved outcomes and

sometimes mitigate the severity of a disorder. Emphasis on early intervention can significantly alter developmental paths and improve outcomes for children at risk of or showing early signs of developmental disorders (National Research Council (US) and Institute of Medicine (US) Committee on Integrating the Science of Early Childhood Development, 2000). These findings will be seen as the generations continue.

As time passes, research and trials must be performed on different age groups and patients with different disorders. Also, regulatory agencies must evolve to this growing industry, which will undoubtedly profoundly affect mental health. According to the British Psychological Society, “We call on the health care regulatory authorities, the leading professional organizations that represent the discipline and practice psychology, and the community of mental health providers at large to cooperate in cross-disciplinary efforts to develop a clinically and scientifically appropriate model for regulation of mental and behavioral health in the ‘digital age’”(Carl et al., 2022).

There are several areas where research can go into improving DTx outcomes. These include additional clinical trials to ensure the safety of interventions and draw conclusions on the long-term effects, determining the benefits of combining treatments with traditional methods for a more comprehensive result, and the value DTx brings to the overall healthcare system.

## ***B. Generative AI Play-based Social Emotional Robot***

### *Social Skills Development*

Social skills are a range of interpersonal behaviors and actions that allow individuals to interact, communicate, and foster favorable connections across social circles. The top five characteristics of social skill development are “(a) peer relations skills, (b) self-management

skills, (c) academic skills, (d) compliance skills, and (e) assertion skills” (Rashid, 2010). These skills are crucial in building peer relationships and creating a positive academic experience in school-age children. “National Association of School Psychologists Center (2002) noted that good social skills are critical to successful functioning in life. These skills enable us to know what to say, how to make good choices, and how to behave in diverse situations” (Rashid, 2010).

“Having difficulties with social skills can come from a variety of reasons, like not knowing how to act in social situations, not having enough opportunities to practice, not getting enough feedback, not being able to understand the cues others are sending, or not getting enough positive reinforcement for doing the right thing. Problematic behavior can make it harder for a child to learn and show prosocial behavior” (Li, 2022). Children who lack social skills have a difficult time making eye contact, taking turns, understanding body language (e.g., standing too close to another person), interrupting conversations, talking only about their interests, inability to redirect when prompted, and failing to use polite forms of conversations (e.g., saying please and thank you). Because of these deficits, children are misinterpreted as rude, mean, inconsiderate and sometimes a bully. Their academic performance suffers, as well as their friendships within their social circle.

There seems to be a lack of understanding of social skills' importance in mental health. Due to the fear that lacking social skills means a child is autistic, parents are hesitant to intervene in therapies and skills groups, which leads schools unable to move forward with interventions. There is a misconception in our society that has caused generations of children to go through their childhood lacking this important cognitive development. “Parents play a vital role in ensuring children develop healthy social skills. But presently, the family structure has broken; therefore, social skills are not being taught properly to their children” (Rashid, 2010).



## *Social (Pragmatic) Communication Disorder*

In 2013, after a fourteen-year review of their diagnosis of mental disorders, the American Psychiatric Association published the revised DSM-5, the Diagnostic and Statistical Manual of Mental Disorders. This manual identified the Social (Pragmatic) Communication Disorder (SCD) as a new diagnosis addressing previous misconceptions. Identification of having a lack of social skills led to a misdiagnosis of having Autism, ADHD, or numerous other mental health disorders. This misdiagnosis caused children to be in the wrong therapeutic settings, identified incorrectly according to the classification tools and failed to meet the child's unique needs. “Previous editions of DSM did not provide an appropriate diagnosis for people with such symptoms, which led to inconsistent treatment across clinics and treatment centers. For these individuals, SCD brings their social and communication deficits out of the shadows of a “not otherwise specified” label to help them get the services and treatment they need” (American Psychiatric Association, 2013).

Therapeutic interventions for SCD have been developed to improve a child’s cognitive development, specifically for those social skills traits. The most common therapeutic options have included speech and language therapy, drama therapy, video modeling, and creating social stories. Socially assistive robots have demonstrated promising capabilities in aiding individuals who face challenges in social communication, encompassing those diagnosed with SCD (Costa et al., 2017).

## *Socially Assisted Robots*

“Robots are devices that use sensors to monitor human movement and positioning and then use this feedback to interact with the environment” (Cano et al., 2021). Traditional robots

detect small movements and changes and cannot adapt their behaviors to react to a situation. The emotional aspect is missing. “The design of a physical robot does not have intelligence or affective behavior and cannot react to the user’s behavior. It cannot, therefore, establish a fluid interaction with the user” (Cano et al., 2021).

Socially assisted robots have been developed with computer systems that can model empathy and adapt to user behavior changes. Rosalind Picard, the author of the book *Affecting Computing*, concluded that it becomes crucial to design computers with the capacity to perceive, comprehend, experience and convey emotions. “She stated that it is important to consider adapting a machine to the affective state of the user or their personality traits, hinting that many systems that have been created focus on logical reasoning rather than emotional aspects” (Cano et al., 2021).

Emotional empathy is a critical part of socially assistive robot development. Emotional empathy is when a person can feel another person’s emotions. For example, if a friend is angry at a situation, you feel angry with them. You connect with your friend on a deeper level of understanding. “The robot should require an affective detection system that recognizes if the child is experiencing positive or negative feelings, as well as reasoning that can be displayed at a cognitive level” (Cano et al., 2021). Many attempts at robot development have been made throughout the years. Some examples include Expressive Robotics Inverse Kinematics (ERIK), which uses color, light and sound to interpret the user's emotional state (Ribeiro & Paiva, 2019). iCub is a humanoid robot that uses imitation as its cognitive architecture (iCub, n.d.). From 1998 to 2021, research has been done on proposed robots and their attempts at emotional communication (Cano et al., 2021).

## *Moxie*

Moxie was developed by Embodied in 2020 as a social-emotional learning companion for children who lack social skills throughout their cognitive development (*The World's First AI Robot for Kids Aged 5-10*, n.d.). Moxie is designed to support social, emotional, and cognitive development through everyday play-based learning and captivating content in children 5-10 years old. The goal is to have a child engage in meaningful play every day. Moxie was created to bring a character to life that encourages children to learn about skills they will use daily before naturally being moved on to direct interpersonal interactions with family and friends (thetechtribune, 2022). Moxie uses multimodal paths of communication that include tracking and interpreting the user's environment, holistically interpreting the user's needs, and ensuring trust between user and robot by incorporating a fast "sense-react loop" (Hurst et al., 2020).

The Moxie robot was developed using a therapeutic framework called the STAR Framework based on situation, task, action, and result (STAR). This approach combines successful behavior programs such as Cognitive Behavioral Therapy (CBT), based on the premise that thoughts (cognitions), feelings and behaviors all influence one another and Applied Behavior Analysis (ABA), the idea that rewarding certain behaviors will lead kids to repeat those behaviors. "Moxie was the only robot that was found that integrates applied behavior analysis (ABA) and cognitive behavioral therapy (CBT) into the STAR framework. The authors considered two domains: (1) communicating social skills and (2) communicating emotional skills. The communication was focused on non-verbal communication, including facial expressions and gestures. Moxie acts as a companion robot, which increases the interest of the child because they feel that they are not alone" (Cano et al., 2021).

A component within Moxie is the SocialX™ platform. This platform is designed to encourage interactions between the child and Moxie. It uses artificial intelligence to support Moxie when responding both verbally and non-verbally to conversations the child may start to engage in. SocialX is a powerful platform for child engagement and allows the child to have a level of comfort with the robot that the child may not have with adults or peers.

Moxie's guiding principles are based on Collaborative for Academic, Social, and Emotional Learning (CASEL), the evidence-based social and emotional learning framework as the core values of education and human development. CASEL is used in schools today to give educators a social-emotional guideline for education.

CASEL's five core competencies are self-awareness, self-management, social awareness, relationship skills, and responsible decision-making. These core competencies are exhibited through weekly themes such as friendship and kindness. Moxie works with the child through different activities to engage in conversation. Additionally, Moxie uses the intelligent tutoring systems (ITS). ITS is a personalized approach that uses technology as a tutor that pivots with the child's moods and personality. Moxie provides feedback in real-time, assesses the emotional responses, and will provide data to further aid in the child's personal experience. "Moxie teaches kids emotional intelligence (you read it right). It also reads with your child and discusses books, does meditations and mindfulness activities, dances, draws, discusses complicated issues like making mistakes, being kind, and navigating emotions, tells jokes and fun facts from history. Your child becomes Moxie's mentor at Global Robotics Laboratory on a mission to teach Moxie how to understand humans better and be a better companion for them" (*The World's First AI Robot for Kids Aged 5-10*, n.d.).

## *Research*

Results of the effectiveness of Moxie are derived from video and recordings of the interactions with the child to determine frustration tolerance, eye contact, facial expressions and overall feelings toward Moxie. The multimodal behavior analytics system reports progress to the parent's companion app, allowing families to track their child's interventions. "Leveraging our STAR framework and the Embodied Moxie within a six-week intervention, we found significant improvements both in subjectively assessed skill categories (i.e., emotion regulation, self-esteem, conversation skills, and friendship skills) as well as quantitatively assessed behaviors such as increased engagement, eye contact, contribution to the interaction, social and relational language" (Hurst et al., 2020).

According to [moxierobot.com](http://moxierobot.com), in the Spring of 2019, an observation study was performed 3 times a week for 15 minutes over 6 weeks. Table 1 displays results that indicate a substantial rise in both subjective and objective evaluations.

**Table 1**

*Spring 2019 Observation Study: Weekly Assessments Over 6 Weeks Showing Significant Gains*

**Subjective Assessments**

43% increase in Emotional Regulation

55% increase in Self-Esteem

21% increase in Conversation Skills

27% increase in Friendship Skills

**Objective Assessment**

5X more eye contact after time with robot

28% increased turn balance by the child

3X more social speech with friends and family

2.5X more relational speech, such as “we & “you”

Positive speech increased significantly versus negative speech

*(The Science Behind Moxie, 2020)*

A second study was performed as part of the Moxie Pioneer Mentor Program. Approximately 50 families nationwide volunteered to participate in the Moxie Pioneer study. Parents in the study were given several assessment questionnaires to complete and report back to the program. These assessments included the Social Skills Improvement System (SSIS), which evaluates social skills, problem behaviors, and academic competence and the Social Responsiveness Scale (SRS-2), which diagnoses and assesses the severity of social deficits. In the study, 71% of children showed some improvement in social skills, with 50% making significant progress, while 69% displayed some improvement in behavior, with 49% showing significant improvement. Notably, neurotypical and neurodiverse children exhibited equal improvements in social skills, with the most substantial changes observed in communication, social engagement, and emotion regulation (The Science Behind Moxie, 2020).

## *Conclusion*

There is much promise in SARs and their use for children. The artificial intelligence of the robots needs to be further explored. There also needs to be a universal approach to designing these robots, ensuring empathy, interaction and facial features are noted. “Out of the studies selected, only 12 models are focused on children with/without ASD, where three studies are for children with ASD. This shows that the design of these intelligent, emotional communication models is still in preliminary development and the results are not yet clear” (Cano et al., 2021).

### ***C. Curriculum-Based Robot for Children with Autism***

#### *Autism Spectrum Disorder*

According to the American Psychiatric Association’s DSM-5, the Diagnostic and Statistical Manual of Mental Disorders, Autism Spectrum Disorder (ASD) is “a complex developmental condition involving persistent challenges with social communication, restricted interests, and repetitive behavior. While autism is considered a lifelong disorder, the degree of impairment in functioning because of these challenges varies between individuals with autism” (APA, 2013). Unlike other mental health disorders, ASD can be diagnosed as early as one year of age, but the functional behaviors will appear more evident as they grow older.

Like Social Communication Disorder, behaviors associated with social communication and social skills increase as the child’s social circles increase. But with ASD, restricted and repetitive behaviors must be prevalent to receive an official diagnosis of Autism. These behaviors may include “inflexibility of behavior, extreme difficulty coping with change, being overly focused on niche subjects to the exclusion of others, expecting others to be equally

interested in those subjects, difficulty tolerating changes in routine and new experiences, sensory hypersensitivity (e.g., aversion to loud noises), stereotypical movements such as hand flapping, rocking, spinning, and arranging things, often toys, in a very particular manner” (APA, 2013).

There are multiple evaluation steps in order to diagnose a child with Autism. Evaluations include parent/teacher questionnaires, similar to ones used in ADHD, and autism symptom measures such as The Autism Diagnostic Observation Schedule (ADOS-2), The Autism Diagnostic Interview-Revised (ADI-R), The Vineland Adaptive Behavior Scales, Third Edition (VABS-3), and Differential Ability Scales, Second Edition (DAS-II) or Mullen Scales of Early Learning (MSEL). A Clinical and Adolescent Psychiatrist determines the official diagnosis. Since ASD has many functional levels, many doctors, such as a child neurologist, occupational therapist, speech-language pathologist and psychologist, may be involved in the child’s care.

“Levels of autism spectrum disorder (ASD) are defined in the Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (DSM-5). The 5th edition criteria for autism diagnosis provides three clear levels based on the patient’s requirements for support. These levels of autism allow specialists to make more refined diagnoses, allowing for more effective treatment plans and helping caretakers better understand individuals’ symptoms and needs” (The 3 Levels of Autism – Diagnosing Autism, n.d.).

Parents must be involved in diagnosing, treating and creating an educational plan to move a child into intervention. Multiple interventions include applied behavior analysis, social skills training, speech and language therapy, occupational therapy, parent maintenance training, special education services, medication, and other treatments for other symptoms a child may experience (Child Mind Institute | Transforming Children’s Lives., n.d.).



## *Robot-Assisted Autism Therapy (RAAT)*

Children with ASD have historically interacted successfully with computer instruction versus the personal instruction of a teacher. “Computers provide predictable responses, are ‘fair’ (all users are treated equally) and do not demand swift in vivo social behavior that can overtax learners with ASD” (Carmona-Serrano et al., 2020). Adults have a very difficult time conversing and keeping up a level of specialized dialogue methods with an autistic child. Some differences between autistic and neuro-typical children are their inability to sustain physical contact, recognize facial expressions, and regulate emotions. These differences make autistic children hard to relate to and deal with for long periods. Many parents look for respite services or, in severe cases, look for long-term residential care in a facility for their child.

“Due to shortage of skilled professionals and prohibitive costs, however, autism interventions are not sufficiently accessible for many families. This reduces autistic children’s chances to reach their full potential, exposes families to mental health problems and reduced productivity, triggering further inequalities. This also exposes the society with high costs of life-long care for autistic people that could be prevented if sufficient prompt and effective interventions were accessible” (LuxAI - Award Winning Social Robots for Autism and Special Needs Education, n.d.). These challenges are what lead to increasing research in Robot-Assisted Autism Therapy.

Robots are being designed to emulate “autism-like” behaviors and to connect to the child and be able to engage easily, unlike an adult would. Possessing such adaptability offers numerous advantages. For instance, interactivity enables the robot to mimic structured interactions to a certain degree. Customizability provides the freedom to create a variety of

behavioral profiles, and repeatability ensures that the interaction can be consistently controlled and reproduced. “Due to their predictability, controllability, and simple social abilities, robots are starting to be used in diverse ways to assist individuals with Autism Spectrum Disorder (ASD)” (Baraka et al., 2019).

### *QTrobot*

QTrobot by LuxAI greatly differs from its competition in robotic-assisted therapy. The body of the QTrobot resembles the size and characteristics of a child. The rotation of the upper body and the video screen as the “face” gives this robot more flexibility and recognition of many facial expressions. The internal hardware and software enable a more streamlined approach to usability for vital benefits such as speech recognition, sound detection and localization, multi-lingual text-to-speech, pose tracking, emotion detection and recognition, image recognition, and face detection and recognition. Additionally, the internal processor and external connectivity to wifi and tablets (Puglisi et al., 2022).

The LuxAI Autism Curriculum sets QTrobot apart from other robots, marking a distinct difference in its implementation. These teaching packages enable the parents to customize the robot’s education plan. Due to the in-depth learning needed for autistic children, QTrobot offers these curricula for various levels of needs. For example, the All About Clothing Curriculum teaches children to prepare for being independent in getting dressed by learning the names of clothing items, their use cases and seasons, dressing sequences and more. Specifically, topics include naming clothing items, matching clothes to seasons, body parts, and occasions, practicing a sequence of getting dressed, and describing clothes. These subjects are crucial for

the autistic community and need to be reinforced often and on a relatable level.(LuxAI - Award Winning Social Robots for Autism and Special Needs Education, n.d.).

### *Research*

There are limited clinical trials regarding QTrobot compared to the other technologies in this report. LuxAI performed a year-long assessment of families who used the platform during the COVID-19 pandemic. The objective behind this approach was to gather impartial perspectives from parents through the utilization of questionnaires. Parents were asked to provide information on the child's past behaviors, educational background, past interventions and their results and an assessment questionnaire. The assessment questionnaire covered the skills covered in the Early Stage Development Curriculum to have an appropriate placement. Each family was given a robot and 2 tablets, one for the parent and one for the child. Parents are acting as the program's facilitators, customizing the educational plan. This program involved the parent directly and gave roles to siblings and other family members. "The analysis disclosed that the robot took over the role of a teacher to a large extent, helping the parents to better separate between their contradicting roles (caregiver and teacher) during the lockdown. It also helped to create a better connection between parents and autistic children and other family members and autistic children. Parents could closely observe the learners' progress, while before, they 'only dropped the kid off in a therapy session and then picked up'" (Hoehn et al., 2023).

### *Conclusion*

Much improvement and studies need to be done to include QTrobot in more autistic homes. The program's limitations include preferred language selection, lack of engagement and technical problems. More work needs to be done in this area of RAAT. The potential for family

involvement is higher than traditional interventions and should bring a higher confidence level in using the technology.

### **III. Methodology**

#### ***A. Building a Website for Disseminating Information***

##### *Culturally and Linguistically Appropriate Services Website*

<https://clas.illinois.edu/>

##### *Case Study 1997-2002*

In 1997-2002, the U.S. Department of Education's Office of Special Education federally funded the Culturally and Linguistically Appropriate Services (CLAS) website. The focus of this project was to provide the public, specifically professionals and families, with resources on the Internet. The CLAS Research Institute's mission was to "identify, collect, evaluate, and provide information to promote effective and appropriate early intervention and preschool practices that are sensitive and respectful to children and families from culturally and linguistically diverse backgrounds" (Boone, 2005, p. 166). In 2003, the University of Illinois took over the website management but has archived it. The resources are still available but have not been updated since 2003.

There is much to learn from the CLAS project in the way we build websites for disseminating information. Similar to what we will see in William Lidwell's book, *Universal Principles of Design*, the CLAS website incorporated numerous principles that enabled users to easily access and navigate the website. For this project, I will list the "four levels of competence necessary to successfully find, access, and use information on the World Wide Web" (Boone, 2005, p. 167).

1. Having computer basics
2. Have web navigation skills
3. Have evaluation/critical thinking skills
4. Have transferability/generalization skills

The first two skills are inherent in how a website is built. A website should be user-friendly, and the navigation bars and links should be easy to find so that the non-computer user will have no problems finding the information. For my purposes, these skills are second nature to users in today's world.

The CLAS website exhibited many considerations that helped users evaluate and think critically about the information presented to them. It is important to allow themselves to ask questions about what resources are right for them, their community and their family member with the disability. Prompts and links are located to be able to go to sections that are appropriate for them. In addition, the website was very cognizant of different perspectives, which gave users a broader range of ideas and opinions.

The final skill considered for the CLAS website was to include predetermined search terms, add excerpts and full-text options, and incorporate videos. Evaluation of this website revealed that users wanted varying degrees of difficulty in their information access. For example, the speed of downloads or video playback was important to users. Some users wanted simple navigational menus stating that they didn't want to complicate their information intake with having to figure out how to use the website (Boone, 2005, p. 169).

## *Key Design Takeaways for Modern Success*

We can translate the user and design principles to a modern website using these important lessons learned from the CLAS website. Some of the following points below are so ingrained in our psyche on what goes into a website. As designers, we do not want users to stop and learn how to access the information. We want a website to be attractive and easy to use so that the audience can spend time on the content versus the navigation.

I have integrated essential design principles into my website to align it with modern standards, which include:

1. Translation capabilities for an inclusive website are available.
2. A database that provides the users with different formats of the material they want to view (i.e., video, print, or downloadable materials).
3. Main menus are accessible on all pages.
4. The content is displayed consistently on all the pages.
5. Videos are streamed on the site without having to leave the site for another.
6. Various types of information include data, parent reviews, medical opinions, research articles, and detailed product websites.
7. User options present a shortened overview with the ability to view longer versions or download to print.
8. Mobile-friendly accessibility had been added.

## *Website Development*

Final Project: [childmindtechnologies.com](http://childmindtechnologies.com)

### *Project Proposal and Plan*

In support of the website development for the site, [childmindtechnologies.com](http://childmindtechnologies.com), a project proposal and a project plan were developed.

#### Project Proposal

Website Development: Emerging Technologies Supporting Cognitive Development In School-Age Children

Project Summary: A website was designed and developed to connect the audience (parents of special needs children, physicians, and special education professionals) to emerging technologies for cognitive development. Targeted behaviors are listed and defined to educate. Next, a potentially compatible technology is introduced and demonstrated to illustrate how it can enhance the behaviors that require attention.

Project Purpose: This project aims to create an awareness of emerging technologies that will enable the audience to advocate for making these interventions available.

Project Audience: There are three audience groups for this project:

1. Parents of special needs children who are frustrated with the lack of improvement in their child;
2. physicians who believe in the potential of new technological advancements in cognitive development;
3. special education professionals who are limited in the ways to help a student



Project Objectives & Goals: The primary objective is to create a resource listing possible alternative technologies to support a child's cognitive development plan.

Strategic Goals of this Project:

1. List the targeted behaviors
2. Define the behaviors for educational purposes
3. Display technological categories (AI Robots, Gaming)
4. Provide additional resources

Project Outcomes: The expected outcomes of this project are to:

1. Make significant contributions to the cognitive development of children
2. Fill the gaps in technology accessibility for special needs families
3. Give families information to advocate for different approaches to interventions

## *Universal Principles of Design*

In the book *Universal Principles of Design*, the author describes how the human brain interprets and explores fundamental design principles. These principles cover graphic and product design, architecture and user interface design. These principles are intended to be universal, meaning they can apply to various design disciplines. The book delves into principles that help designers create more effective, user-friendly designs. In my case, a website.

For this project, I considered these principles as much as possible. These include alignment, color, figure-ground, good continuation, hierarchy, legibility, proximity, similarity, and symmetry. These principles are fundamental guidelines that helped me create a more effective and user-friendly website.

In the following section, I illustrate through visuals the application of storytelling, chunking, highlighting, and consistency within my website.

## User Experience Design Principle: Storytelling

In *Universal Principles of Design*, storytelling is defined as “a method of creating imagery, emotions, and understanding of events through interaction between storyteller and an audience” (Lidell, 2003, p. 230).

On the “My Story” page, I highlighted my motivations and reasonings for developing this website and capstone project collectively. In Figure 1 I give a description of each fundamental element of storytelling as it pertains to my website.

**Figure 1**

### *The Fundamental Elements of Storytelling*



Setting: My world

Characters: My family

Plot: Throughout the story, the copy is written as a timeline of events that mark the important revelations and milestones.

Invisibility: Hopefully, my story captures the viewer's attention and is relatable to them.

Mood: The premise of my journey with my boys' struggles with mental health is inspirational and motivating to the viewer.

Movement: The whys, the timeline, and the progression of the boys' stability throughout their elementary and middle school years create a flow throughout the story.

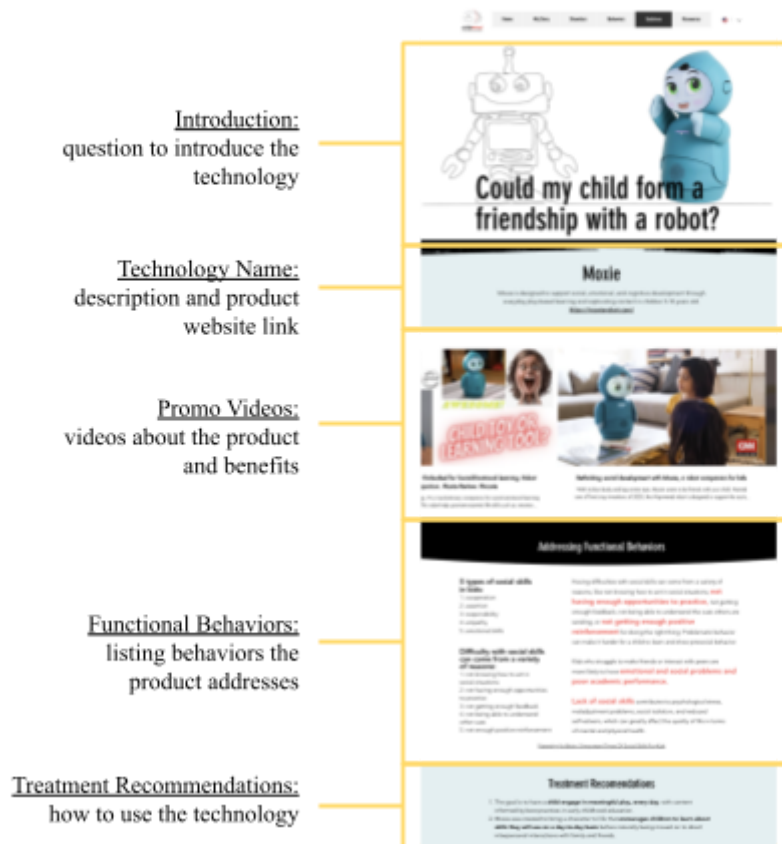
## Graphic Design Principle: Chunking

In *Universal Principles of Design*, chunking is defined as “a technique of combining many units of information into a limited number of units or chunks, so that the information is easier to process and remember” (Lidell, 2003, p. 40).

Lidell describes chunking as “the technique of chunking seeks to accommodate short-term memory limits by formatting information into a small number of units” (Lidell, 2003, p. 40). This technique is used to help the target audience recall all the product information and recall how these products pertain to their child’s disorder.

**Figure 2**

### *The Principle of Chunking*



## User Experience Design Principle: Highlighting

In *Universal Principles of Design*, highlighting is defined as “A technique for bringing attention to an area of text or image” (Lidell, 2003, p. 126).

On the page “Disorders”, there are three blocks of copy defining the disorders that I focus on. Highlighting allows the viewer to immediately see the red keywords that point out the behaviors associated with the disorder. This principle was an important element for the user since behaviors are a crucial point of reference to understanding cognitive development.

**Figure 3**

*The Principle of Highlighting*



## Graphic Design Principle: Consistency

In *Universal Principles of Design*, consistency is defined as “the usability of a system is improved when similar parts are expressed in similar ways” (Lidell, 2003, p. 56).

Throughout all the pages on my website, I use consistent transitional design elements. These elements are especially evident on the three Product Solution pages. All three have similar product introductions, product descriptions, section dividers, fonts, colors, and element sizes. Lidell states that one should “consider aesthetic and functional consistency in all aspects of design” (Lidell, 2003, p. 56). I think this principle was used successfully as the content is uniquely established within an area and simple for the user to follow along and understand.

### **Figure 4**

#### *The Principle of Consistency*

Each page has a consistent header that includes a line drawing, a product image, and a headline in the same font, size and color.

The next area has the same colored background, same product name font, description type style and link to the product’s website.

The next area is the video section with consistent styling of the videos, a video title and description.

Throughout the site, similar transitional elements are used as well as fonts, sizes, and callouts.



## *Child Mind Technologies Branding and Logo Design*

Branding is a strategic marketing process that involves creating a distinct and memorable identity for a product, service, or organization. There are various types of branding strategies, each with its own purpose and approach. For my project, I created a personal brand to define my website and my initiative.

What is Personal Branding? “Personal branding is the act of promoting yourself as a brand by crafting a distinct identity, reputation, and online presence to showcase your skills, expertise, and personality. This type of branding is normally used by professionals, influencers, and entrepreneurs to enhance their careers, attract opportunities, and build a strong online presence” (American Marketing Association | AMA, n.d.).

“ChildMindTechnologies.com” started as a domain name idea. From there, I developed a brand that reinforced my mission: identifying technology to support children's mental development, learning, and well-being. Creating a brand identity is a comprehensive process that involves various steps to ensure consistency, appeal, and effectiveness in communicating with your target audience.

1. Define the Brand: Clearly define what “ChildMindTechnologies” stands for.
2. Logo and Design: Create a logo and website design that reflects the nature of your brand.

Logo design is important for several reasons, as it plays a significant role in establishing a brand's identity and conveying its message to the target audience. A well-designed logo is a visual representation of your brand. It serves as a memorable symbol that can be easily recognized. When envisioning the Child Mind Technologies logo, I wanted to stay away from the typical icons associated with the brain and technology. I chose a design with a more artistic flare due to the tone I created for my website. In keeping with the branding, I chose the colors and typefaces that coordinate with the website.

**Figure 5**

*Logo Design: Child Mind Technologies*





## IV. Conclusion

In conclusion, the critical issue of children's mental health, particularly in the wake of the pandemic, has brought to light the pressing need for new ways to support school-age children in their cognitive development. This increased attention on mental health has highlighted all the different ways we as a society look at early intervention in children. With the growing influence of technology in our daily lives, this field has opened up a unique prospect for digital interventions to have a meaningful impact.

Undiagnosed or untreated mental health conditions in children can have long-lasting repercussions, affecting their educational, social, and personal lives. The research indicating that the brain fully develops at age 25 underscores the importance of early interventions to ensure healthy cognitive and emotional growth. Therefore, utilizing technology for these interventions has become increasingly prevalent.

As we move forward, the emphasis should be on making these digital interventions widely available to ensure that all children, regardless of their backgrounds, can access the support they need. The ultimate goal of this paper has been to explore the potential of emerging digital interventions in improving the mental health of children with deficits in cognitive development. This digital data collection and assets are subsequently incorporated into a website, making it readily available to families, educators, and medical professionals who wish to conduct additional research tailored to their needs.

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