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An Undergraduate Project on Topic "Design and Development of a Low-cost Bangla Voice Interactive Children Educational Robot "TINY" for ASD Application"

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An Undergraduate Project on Topic "Design and Development of a Low-cost Bangla Voice Interactive Children Educational Robot "TINY" for ASD Application"

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Department of Computer Science & Engineering

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Testimonial

We understand what plagiarism is and how strict the university's anti-plagiarism policy is. This is our original work, we attest to that. Additionally, any third-party software or text included in this project is properly cited and compliant with well recognized academic standards.

Ahsan Mahbub

Name	Signature Date

Nohori Jobaida

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Jafrin Khan

Name	Signature Date

Acknowledgement

We commence by offering our heartfelt gratitude to the Almighty Allah for endowing us with the fortitude, perseverance, and capability to diligently embark on and successfully complete our senior project. Our profound appreciation extends to Dr. Mohammad Shidujaman our esteemed Supervisor, Assistant Professor of Independent University, Bangladesh. Their invaluable guidance, boundless patience, and devoted investment of time have been instrumental in steering us through the intricacies of our project journey and shaping the formulation of this comprehensive report. Under their expert tutelage, our project progressed seamlessly, and their insightful counsel proved indispensable at every juncture. In order to make the defense session both productive and enriching, we would like to sincerely thank the committee members for their invaluable services. Their insightful criticism and priceless suggestions greatly enhanced the breadth and caliber of our effort.

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Letter of Transmittal

Dr. Mohammad Shidujaman
Senior Project Supervisor, Assistant Professor
Dept. of Computer Science and Engineering,
Independent University, Bangladesh.

Subject: Senior project report on "Design and Development of a Low-cost Bangla Voice Interactive Children Educational Robot "TINY" for ASD Application"

Dear Sir,

The opportunity to submit a senior project report on "Design and Development of a Low-cost Bangla Voice Interactive Children Educational Robot "TINY" for ASD Application" to you is really appreciated. The knowledge and work we put into the project under your direction is fully reflected in this report. We used a wide range of abilities and cutting-edge technology throughout the project, which improved our comprehension and expertise in this area. We think that this paper successfully achieves its goal. Your invaluable advice, mentorship, expertise, and support are greatly appreciated. We hope that this report satisfies your needs and meets your desires. We thankful for your unwavering collaboration and priceless help throughout the semester.

Your Regards,

Nohori Jobaida (1931154)
Ahsan Mahbub (2030472)
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Department of Computer Science and Engineering,
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List of Abbreviations

1) ABA - Applied Behavior Analysis

2) AI - Artificial Intelligence

3) ASD - autism spectrum disorder

4) CRI - Child-Robot Interaction

5) CT - Computational Thinking

6) CwASD - Children with ASD

7) ECE - Early Childhood Education

8) ER - Educational Robot

9) ESP - Espressif Systems

10) HRI - Human-Robot Interaction

11) NLP - Natural Language Processing

12) SARs - Socially assistive robots

13) STEAM - Science, Technology, Engineering, Arts and Mathematics

14) TINY - Teach, Inspire, Nurture, Yeild

Abstract

Autism Spectrum Disorder (ASD) presents challenges in areas such as communication, social interaction, and learning. To address these challenges, TINY has been developed as an interactive educational robot tailored to meet the unique needs of children with ASD. TINY incorporates adaptive AI technology, allowing it to personalize teaching methods and activities based on each child's individual preferences and developmental progress. Its features include sensory-sensitive design, engaging interactive elements, real-time emotion detection, and gamified learning to foster cognitive and social skills in a stress-free environment. The robot also provides a valuable link between caregivers and professionals by generating detailed progress reports and actionable insights. These reports help in understanding the child's learning patterns and informing targeted therapeutic approaches. By combining advanced technology with empathy-driven design, TINY aims to create a nurturing educational experience that promotes skill development, enhances emotional well-being, and supports overall growth in children with ASD.

This study outlines the design, functionality, and impact of TINY, demonstrating its potential to revolutionize learning and therapy for children with ASD.

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Chapter 1

Introduction

The project -Design and Development of a Low-cost Bangla Voice Interactive Children Educational Robot TINY for ASD Application, showcases a meaningful advancement in educational technology for children with Autism Spectrum Disorder (ASD). This initiative, undertaken by the Computer Science and Engineering Department, underscores our commitment to leveraging technology for societal benefits. By creating an affordable, interactive robot designed to engage children through Bangla voice interactions, we sought to support language learning and engagement in a way that is both accessible and impactful. This project was an invaluable opportunity to apply theoretical concepts in robotics, voice interaction, and human-centered design, allowing us to address the unique educational needs of a specific demographic in Bangladesh. The experience reinforced the department's mission to nurture innovation and contribute toward the goals of Digital Bangladesh.

1.1 Background of the Work

Educational robotics is to improve children's skill and competency development via the use of electronic components and robots in an interdisciplinary learning environment. It focuses mostly on the STEAM fields, but it can also touch on subjects like geography, history, and languages. STEAM education relates to these 5 subjects: Science, Technology, Engineering, Arts and Mathematics [1]. In recent years, educational robotics has become an essential tool for facilitating active learning. It allows students to engage in hands-on activities that promote exploration and innovation. The integration of robotics into educational curricula has proven to enhance cognitive development, improve technological literacy, and encourage collaboration among students. Educational robots are designed to interact with children, providing immediate feedback and personalized learning experiences that cater to individual needs and learning styles. The capacity with which children could interact with a social robot in a novel learning environment is being studied. A method for measuring how actively children with learning difficulties participate in adequately prepared activities is described, utilizing multimodal machine learning. The goal is to find the child's sustained attention throughout the conversation. To achieve this goal, visual and aural data are recorded between the children and the robot [2]. Educational robots for children are emerging as tools for learning that can enhance children's early reading and language skills, considering recent technical developments [3]. Social robots are those that can interact with humans on a mental and social level. Socially assistive robots (SARs) have been used in recent studies to help children with special needs communicate better and interact with others [4].

Figure 1.1: Fosters STEAM Learning and Educational Robot

One of these conditions is ASD. Autism Spectrum Disorder (ASD), a neuro-developmental disease signified by limited interests, social communication challenges, and compulsive practices [4]. Children with ASD often struggle with social interactions and communication, which can hinder their academic and personal development. To address these challenges, socially assistive robots (SARs) have been developed as therapeutic and educational tools to support these children [5]. Today, a wide range of assistive technology applications, including robotics, telehealth, virtual reality, and computer-assisted learning, have been developed to aid in the treatment of autism [6]. According to recent research, children with autism are more likely to engage with an interactive robot. These robots are equipped with sensors and algorithms that enable them to recognize and respond to human emotions, gestures, and speech. The robot can guide the children in therapy sessions to practice more complicated types of interaction found in social human to human relationships by engaging them in ways that model and teach fundamental parts of human interaction [7].

Educational robots hold significant potential for enhancing the learning experiences and developmental outcomes of children with ASD. The ability to communicate verbally and nonverbally, recognize emotions, and acquire social skills are the main characteristics of

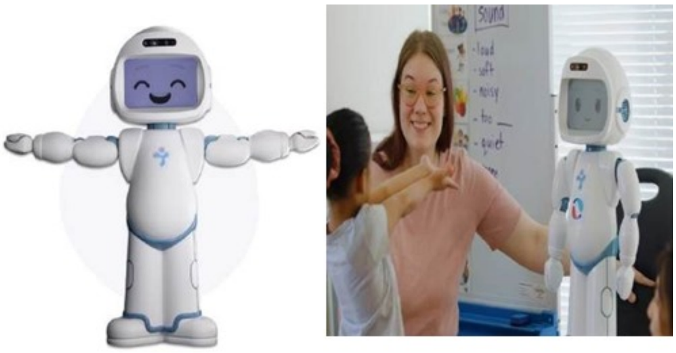


Figure 1.2: QTrobot and Autism Education with Qtrobot

SARs. In this regard, their ability to be programmed to respond to various social circumstances is one of their biggest strengths. Not only provides robotic assisted therapy perfectly align with the educational needs of these students, but it also perfectly corresponds with the methodological principles (individualized intervention, sequence of activities, active experiences, and predictive environments) that should guide their teaching-learning process. This kind of intervention must be used in educational environments according to the rapidly advancement of robotics, its positive outcomes, the complexity of the educational demand, and increasing prevalence in ASD cases [9].

Figure 1.3: L'oeil Creatif with his Cozmo Robot for ASD children

1.2 Significance and Scope

The development of a Bangla-speaking educational robot for children has been driven by the growing recognition of the critical role technology plays in education and the need to provide interactive and engaging learning experiences in the Bangla language. Educational robots are instrumental in helping children develop essential cognitive skills and enhance their overall learning experience [10].

Figure 1.4: Jibo Robot for ASD children

Children diagnosed with autism spectrum disorder (ASD) in Bangladesh face significant challenges when it comes to receiving specialized educational and therapeutic interventions tailored to their individual needs and skills. The current resources and therapies available often lack cultural relevance, accessibility, efficacy, and efficiency. This gap in services is compounded by a shortage of resources and qualified personnel dedicated to supporting the social, emotional, and academic development of children with ASD. Children with autism spectrum disorders (ASD) are accepted into primary school with the goal of helping them participate in social activities within the classroom and school community in addition to helping them develop their academic skills. By encouraging crucial target behaviors including imitation, eye contact, taking turns, and self-initiation, robots in autism therapy serve as behavior eliciting agents, accelerating the development of a patient's sensory, cognitive, social, emotional, and motor capabilities [11]. The long-term objective is not to build robots that will take the place of human therapists, instead attempting to provide them with crucial information that allows the therapists to customize the therapy material and generate more interesting and realistic interactions between the robots and autistic children [12]. The Bangla-speaking educational robot is

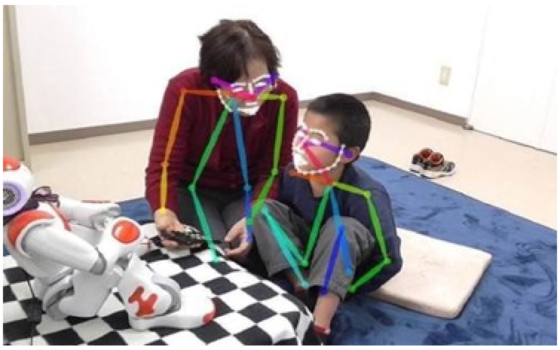


Figure 1.5: Therapy session augmented with humanoid robot NAO

a culturally relevant tool for children with ASD in Bangladesh. It enhances learning and engagement, improves communication skills through speech recognition and NLP (Natural Language processing), provides personalized support, fosters social skills through interactive activities, and supports educators and therapists by providing resources and support. The robot's integration with the learning pace and needs of each child ensures effective interventions.

1.3 Objective

Our designed robot TINY, a theoretical foundation for social robotic education, which stands for Teach, Inspire, Nurture, and Yield. The goal of this project is to develop an interactive educational robot, this robot capable of speaking Bangla, specifically designed to engage and educate children in Bangladesh. By leveraging robotics and artificial intelligence. The purpose is to offer children an engaging and immersive learning environment that improves their cognitive abilities, linguistic fluency, and subject-matter knowledge by utilizing robots. Additionally, our robot explores the potential of low-cost support for early language acquisition and literacy development. Our robot TINY has the ability to improve social interaction, communication, and emotional regulation skills in children with ASD. The project aims to provide insights into future research and development of assistive technology for children with ASD by documenting the development process, findings, and best practices and sharing them with the larger educational and therapeutic community.

Figure 1.6: TINY robot for ASD children

The main objective of TINY:

- TINY is capable of speaking Bangla.
- Aims to assist autistic children in Bangladesh and improve their behavior.
- Provides an engaging learning environment that enhances cognitive abilities, linguistic fluency, and subject-matter knowledge.
- Responds quickly and accurately to questions, exploring potential of low-cost support for early language acquisition and literacy development.
- Improves social interaction, communication, and emotional regulation skills in children with ASD.
- Aims to provide insights into future research and development of assistive technology for children with ASD.

Chapter 2

Literature Review

Literature review is applied in system-wide research projects. Its goals are to gather data, identify issues as they arise, and improve the performance of the built system. A literature review also makes it possible for system administrators and users to identify the real issues with the current setup.

2.1 Children educational robot

Robotics education transfers information about robotics or other topics by using instructional robotics technology. Research has attempted to show how robots may be used in teaching, particularly for younger pupils. The findings about the children's methods of problem-solving during debugging revealed that most of them employed decomposition to handle the task's complexity. These findings are significant because they demonstrate that even at these early ages. The results of the children's techniques for addressing problems during debugging showed that most of them used deconstruction to deal with the complexity of the task [13].

Figure 2.1: Sanbot children educational robot

2.2 Effects of robot programming in early childhood education

Commencing robot programming at a very young age, like 3 years old represents a constructive approach. Robot programming employs symbolic and pictorial commands, requiring students to direct a robot's movement and construct commands in a suitable manner to produce a series of actions. CT skills will be necessary for future generations, and their significance in ECE is increasing as age-appropriate devices become accessible. Programmable robotics has recently been used to bring programming and Computational Thinking (CT) into Early Childhood Education (ECE)[14].

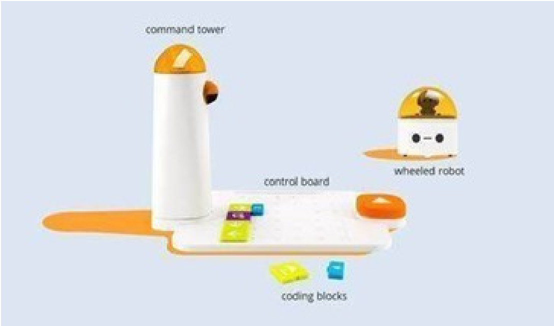


Figure 2.2: Matalab coding robot

2.3 Improving social skills and behavioral improvement using social robots

By combining advanced robotics technology with the concepts of behavioral therapy, a Human Robot Interaction (HRI) system is being developed to improve the behavioral abilities of children with autism. The system provides controlled practice opportunities by responding to the child's behavior and emotional cues through the use of sensors, actuators, and artificial intelligence [16]. Additionally, a long-term in-home social robot can help children with autism spectrum disorder (ASD) by developing a strong connection with them and helping them with their social skills inadequacies [17]. Parents and other caregivers can actively contribute to their child's social skill development by modifying interactions with the robot based on the child's preferences and developmental stage.

Figure 2.3: MIKO robot

2.4 The role of educational robotics for inclusive education

Two inclusive education philosophies that do not conflict with one another; rather, they just address how inclusive education is perceived. One is where help is given to students with various special needs in the context of inclusive education, seeing special needs as disabilities, as well as those from diverse cultural backgrounds, socioeconomic backgrounds, gender identities, and others [14].

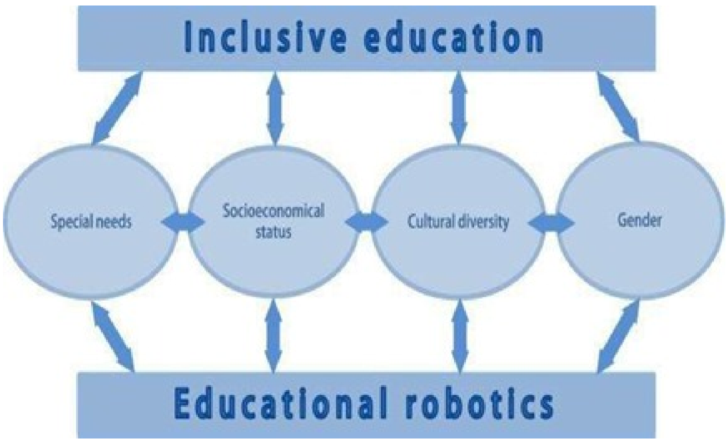


Figure 2.4: Concept of Interrelations among Inclusive Education Robotics

2.5 Improving language skills and development using educational robot (ER)

Robot tutors with gesture abilities can prove to be useful. Gestures help less-skilled learners understand speech in a second language. Since the robot can understand English spoken by children studying it as a second language, it can help children become improved in the language by processing partial words and sentences and enhancing their grammar and pronunciation [17]. Language abilities like speech and vocabulary might be improved by social robots. Children played activities like picture naming and matching to learn new vocabulary and they conversed with a social robot [18]. It has been discovered that students find robots to be generally enjoyable and that they even have a favorable impact on their performance. However, in scenarios involving learning new languages, robots may perform a variety of functions. Here, the robot taught English terms for ideas that the youngsters, ages 5 to 11years. Children were not exposed to any English vocabulary at all. Another study reveals that children's participation in an animal name learning game was influenced by the robot's unpredictability in providing feedback. However, the feedback itself had no effect on the children's learning gain, which was minimal but continuous throughout every situation [19].

Figure 2.5: Talkbo and EMY Educational Robot

2.6 Prerequisites regarding using social robots with ASD children

The design of social robots determines how a child will interact with them. Researchers have proposed that distinct design elements and morphologies can improve therapeutic efficacy; some have used humanoid robots, while others have used non-humanoids. When creating robots for autism therapy, factors including autonomy, safety, functioning, and appealing features must be taken into account [20].A socially assistive robot can offer personalized, on demand, structured cognitive or social support, enhancing social and communicative skills in both human-robot and human-human interactions, thereby enhancing healthcare efforts [21]. Although there are many opinions whether the robot should be more human-like or not in making a difference, as some say certain children with autism spectrum disorder (ASD) are more comfortable with robots that don't seem like real people as they are less complex and less, but others support a humanistic mindset.

Daily living skills can be more broadly applied in a genuine healthcare setting as realistic looking robots are better able to comprehend social behaviors through their movements and attributes [22].

a) Kiwi b) Leka c) Paro d) Parrot

Figure 2.6: Different Shaped Educational Robots for ASD Children

Above are some of the social robots used for autism. Researchers have explored the promising utility of socially assistive robotics (SAR) as a therapy tool to help people, particularly children, with autism Kiwi, a Stewart Platform designed for research in socially assistive robotics. Children interact with Kiwi by playing 10 different educational games on a touch-screen monitor [23]. Leka a social robotic partner for kids with autism spectrum disease that helps them with their physical development [24]. Lastly the social robot Paro is intended to lessen psychiatric problems, enhance communication, and boost involvement and attention spans. Its social interaction promotes greater engagement and focus [25]. Animal robot like parrot can be controlled by a remote operator to detect and interact with autistic children verbally [26].

2.7 Educational robots for ASD children

In recent years, there has been a great deal of interest in examining the efficacy of technology based strategies in training and teaching different skills, such as communication and social skills, academic skills, and information processing, to increase independence in children and adolescents with ASD [24]. A number of studies have been done that showcase the work between robotics and artificial intelligence (AI), with a special emphasis on the growth of children with ASD. Every study highlight of the modern innovations made for improving learning environments and handling certain problems.

Table-1: List of some used educational robots for ASD children

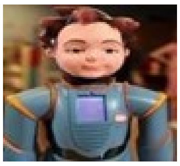
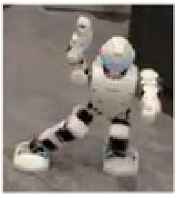
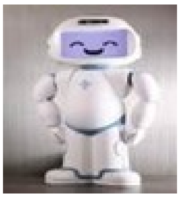
Research	**Robot**	**Application**
Kaspar, the social robot and ways it may help children with autism – an overview [20]		A social companion to improve the lives of children with autism and other communication difficulties through facial expression recognition and real-time image processing.
Milo: This robot used in therapy for children with autism spectrum disorder [22]		Support children with ASD in developing their social and emotional abilities.
Effectiveness of NAO Robot to Train Children with Autism Spectrum Disorder (ASD) [9]		Help to improve the academic skills of the children through interactive sessions.
Otisma:An integrated application and humanoid robot as an educational tool for children with autism [15]		Integrates applied behavior analysis (ABA) to assist children with autism in improving their social skills and communication abilities.
Social and emotional skills training with embodied Moxie [23]		Provides information that is influenced by cognitive behavior therapy, graded cueing, and applied behavior analysis, among other therapeutic approaches.
Children with autism spectrum disorder can learn emotional skills from socially assistive robots [21]		Robot for therapists and educators. It uses facial expressions, gestures, and games to teach children with autism spectrum disorder about communication, emotions, and social skills.

Table 2.1: Robots and Their Applications for Children with Autism

2.8 Robotic learning assistant with AI features for children with ASD

A social robot with an AI-based state detection system is a significant advancement for educational settings and assisting children with various needs. This technology allows the robot to sense children's emotions in real time and respond competently. In educational contexts, this technology can enhance learning outcomes and mental health, particularly for children with autism spectrum disorder (ASD). In therapy environments, educators and therapists are able to foster genuine connections and tend to personal requirements by utilizing the robot's ability to perceive and respond to emotions [21].

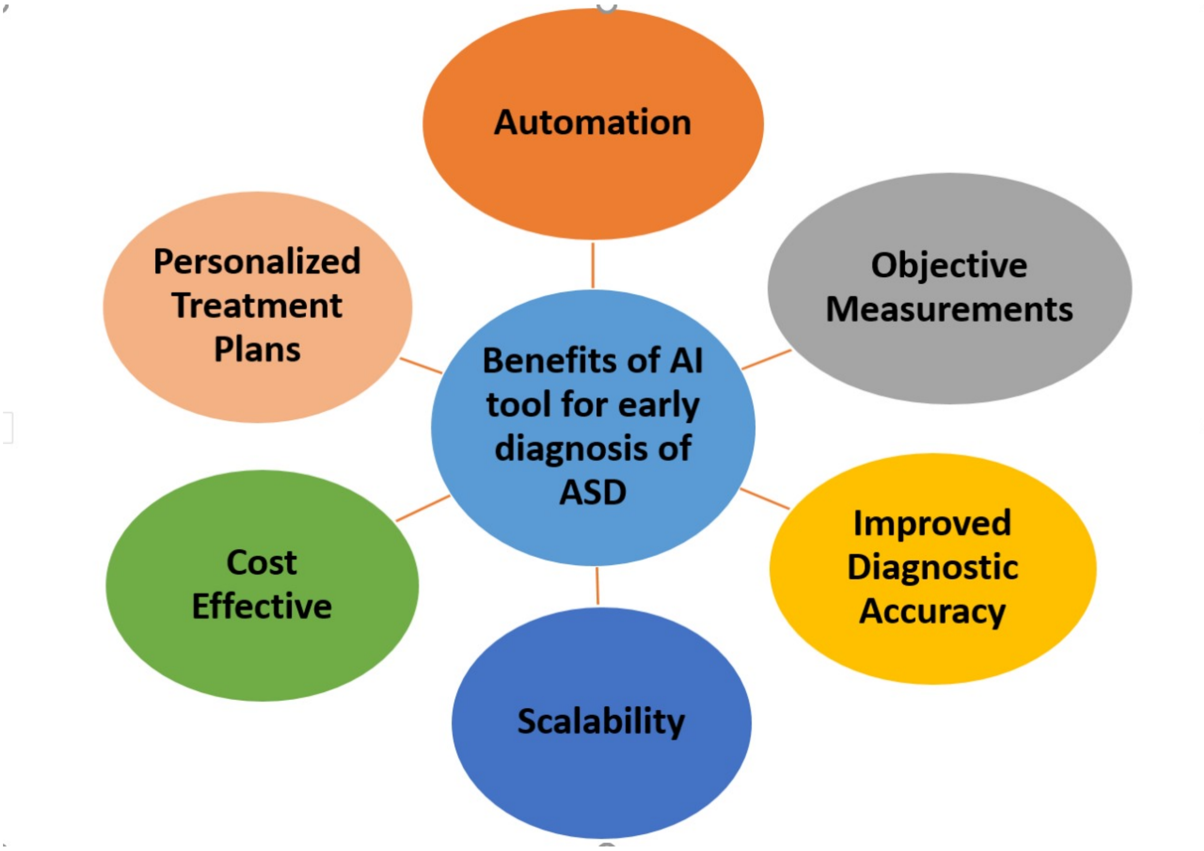


Figure 2.7: The benefits of AI tools for children with autism

2.9 ASD related work in Bangladesh

Few studies in Bangladesh have explored the use of robotics in addressing Autism Spectrum Disorder (ASD) in children. These studies used the NAO robot to improve communication and social interaction in children showing higher levels of participation [22,23].Another study focused on a humanoid robot designed to address communication barriers, social interaction difficulties, anxiety, and behavioral challenges. It specifically addresses the issues with nonverbal asd children [24]. These studies highlight the potential of robotics as a therapeutic tool, but highlight the need for localized, cost-effective, and culturally appropriate solutions in Bangladesh. More adaptation and evaluation are needed to fully realize the potential of robotics in the treatment of ASD.

Figure 2.8: Image of humanoid robot

Chapter 3

System Design of TINY

The hardware and software components of TINY's system design are combined to enable data processing, environment monitoring, and human interaction. Tiny is the primary processor unit that controls systems and does complex calculations. It interacts with kids by processing their oral input through speakers. The software includes modules for Natural Language Processing (NLP) algorithms that evaluate user inputs in order to enable dynamic interaction between users.



Verson-1 Version-2 Version-3

Verson-4 (Latest)

Figure 3.1: All versions of the TINY robot

3.1 Recognizing the circumstance

Start by being aware of the special requirements and difficulties that children with ASD confront. Take into account their limited social engagement, sensory sensitivity, and communication challenges. Recognize the importance of language proficiency for participation in society, education, and expressing demands. The goal of our robot should be to aid with the development of languages. The primary functions of TINY, for example:

- Enhancing communication skills
- Improving social interaction
- Encouraging the expression of emotions
- Promoting concentration and attention during the learning process.

3.2 The components and characteristics

- **Sensory Observation:**In order for TINY to sense its surroundings and recognize signals, it needs to be outfitted with sensors (such as camera and microphone). To react to physical interactions, take into consideration adding touch sensors.
- **Communication:** To interact with children, TINY can employ voice recognition and synthesis. Visual signals that are expressive, like LED lights or facial characteristics, can improve communication.
- **Expression of Emotions:** Expression actions, such as motioning and smiling, can promote interaction and communicate feelings. Depending on the child's emotional state (e.g., relaxed, passionate), TINY may behave differently.
- **Concentration and Awareness:** Monitor the teacher's voice during online classes and redirect the child's awareness when needed. Use expressive behavior (e.g.turning toward the teacher) to guide concentration.

3.3 Interaction design

- **Predictability:** Ensure that TINY's interactions are predictable and consistent. Children with ASD often thrive in structured environments. Avoid sudden movements or surprises that might cause anxiety.
- **Triadic Interaction:** Facilitate interactions between TINY, the child, and the teacher. TINY can act as a mediator, reinforcing positive behaviors and maintaining engagement.

- **Independence:** Balancing robot assistance with the child's independence.
- **Emotional impact:** Ensure TINY's interactions are supportive and not distressing.

3.4 Interaction model of robot, teacher/ supervisor and ASD children

Our robot TINY aims to create a supportive learning environment for children with ASD while leveraging the capabilities of a humanoid robot. Here are some key points:

- **Functionality of the Robot:**The humanoid robot serves as an assistant or companion during educational and therapeutic activities. It interacts with children in a structured and predictable manner, providing consistent cues and responses. The robot's presence can enhance engagement, communication, and learning.
- **The objective of the Teacher/Supervisor:** The teacher or supervisor is responsible for directing the interaction. They let the child and robot communicate with each other. The instructor makes certain that the tasks are in line with each child's unique requirements and objectives.
- **Socially Assistive Robots (SARs) and Their Role in Interventions:** SARs are looking at using SARs as tools to help kids with ASD. The use of Human-Robot Interaction (HRI) in interventions can be advantageous. SARs can help children interact with others, which may help to improve social skills and lessen autistic behavior.
- **Safety Architecture:** Implementing robots in autism interventions requires safety considerations. A safety architecture is proposed to integrate into the robot's controller. Its main objective is to identify distracting factors that may compromise the psychological or physical safety of the children. Testing in a Simulated Environment: A kid and robot engage in a simulated setting. The interaction is created by dialogue inputs and outputs.

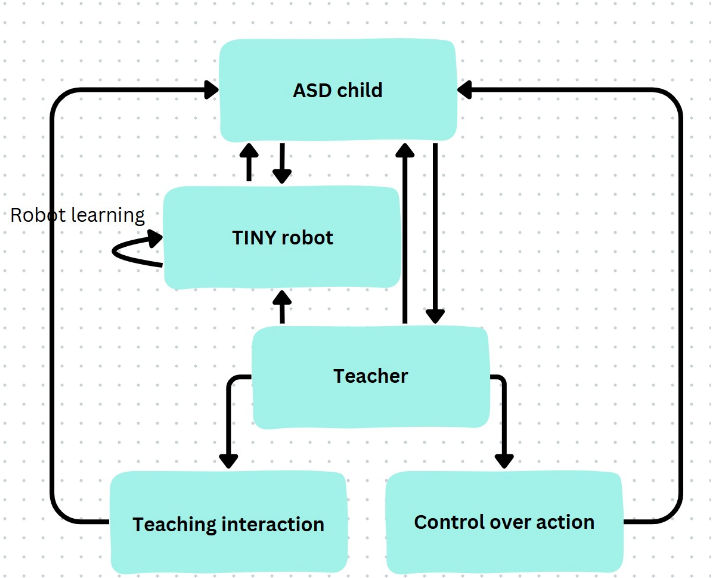


Figure 3.2: Interaction model of TINY robot

3.5 Methodology for the development of TINY

The inception of TINY, an interactive educational robot, marks a significant stride towards revolutionizing early childhood education. By helping kids develop their social skills and customizing teachings through one-on-one interactions. TINY paves the way for a dynamic and immersive learning experience. This educational robot aimed at assisting children aged 3 to 11 age in learning basics like alphabets, numbers, and general knowledge. Even it can be assisted for quick replies and general knowledge-based questions. This implies that they have an easier time with things like science, arithmetic, and linguistic vocabulary. To make this happen, it is meticulously crafted with sophisticated software components and robust hardware. This document illustrates a holistic system design that brings life into the miniature, presenting it as an interactive, educative, and safe learning medium. The first step is to establish clear learning objectives that prioritize basic knowledge. Components like the Raspberry-Pi 5B, microphones, audio amplifiers, sensors, and more are carefully selected and acquired to meet educational needs. TINY is designed using safe and child-friendly components. This 3D model is also given the easy name "TINY" to make the robot more acceptable to children. The hardware is assembled according to the design, with each part, especially the sensory and motor units, undergoing thorough testing for functionality and safety. Software development is next, with programs enabling TINY to engage with children through voice recognition and educational algorithms. This software is integrated with the robot's hardware, allowing for sophisticated interaction. Extensive testing ensures TINY's reliability and safety, leading to design and software enhancements that improve the robot's educational interactions. It is then tested with a group of children, whose feedback is vital for assessing the robot's educational effectiveness. The feedback forms further improvements to TINY's design and educational content. The development journey is documented, producing materials to support TINY's distribution and use. Finally, outreach to educators, parents, and tech enthusiasts allows for showcasing it and incorporating community feedback. Children with ASD may benefit from robot-assisted therapy in terms of social interaction, communication, and emotional control, but further study is required to make this possible.

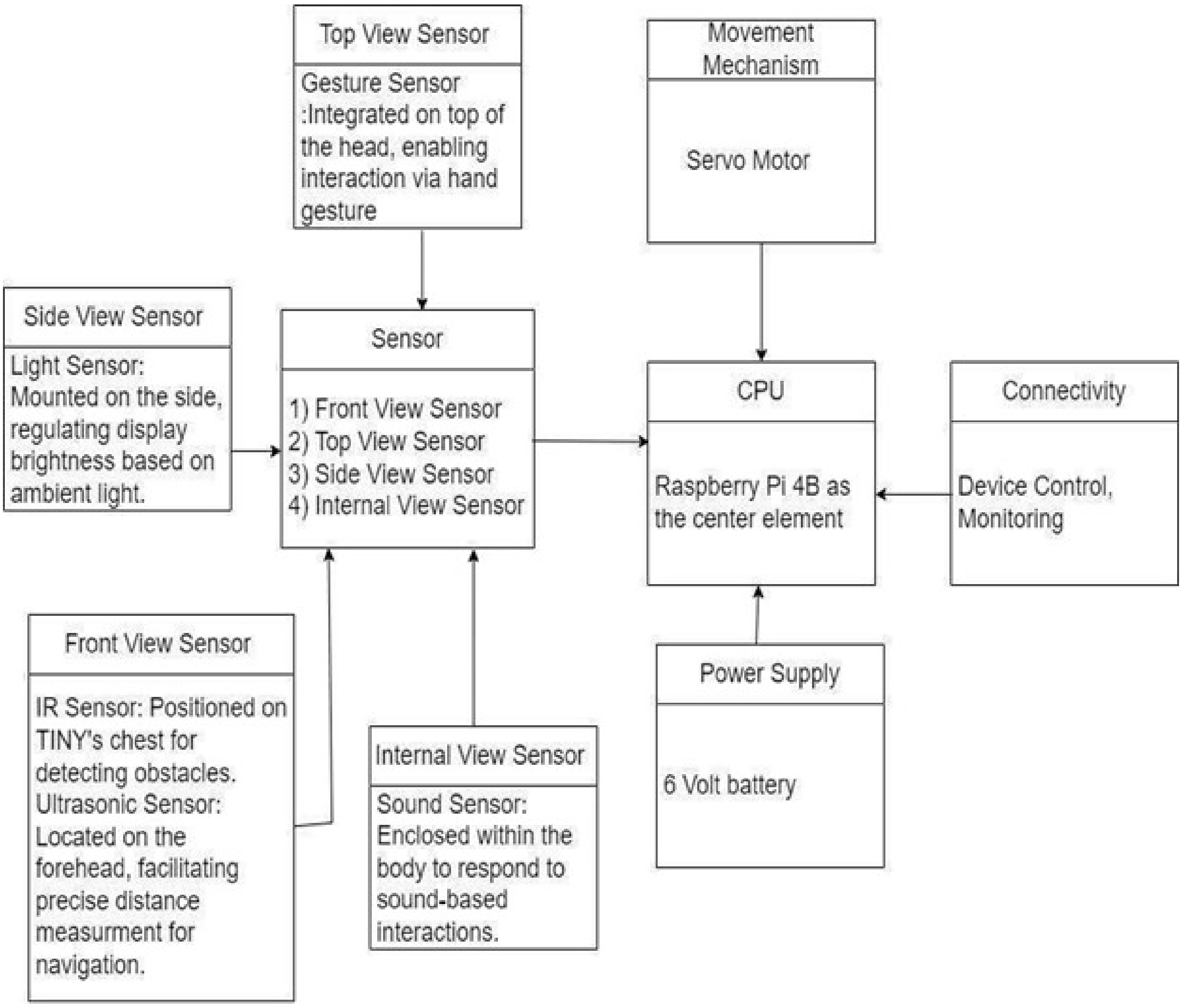


Figure 3.3: Block diagram of robot TINY

Chapter 4

Architecture of TINY

4.1 Framework of architecture

TINY acts as the central processing unit, enabling it to perform complex computational tasks and control mechanisms. To process spoken inputs from children and interact with them through speakers [20] [21]. An output tiny communicates with children using an i2's audio amplifier and speaker. For movement it uses two legs but it also could enable bipedal or multi legged movement. Its movement will help it to be physically engaged with children while learning or communicating. Its body is super lightweight and strong. Maintaining durability and lightweight we have used a 3D printed body. It supports TINY's power management and is handled by the battery charging module paired with a battery, ensuring that tiny has a consistent and rechargeable power source for continuous operation. For single cell lithiumion batteries, the tp-4056 is a linear charger that operates at a fully constant voltage and current. The tp-4056 is a perfect fit for portable applications because of its sop packaging and minimal number of external components. Furthermore, the tp-4056 is compatible with both USB and wall adapters. TINY's interactive learning experience by allowing it to respond to physical touch. TINY is envisioned as a versatile, interactive robot that can move, perceive, and interact with children, enriching their educational experience [22] [23].

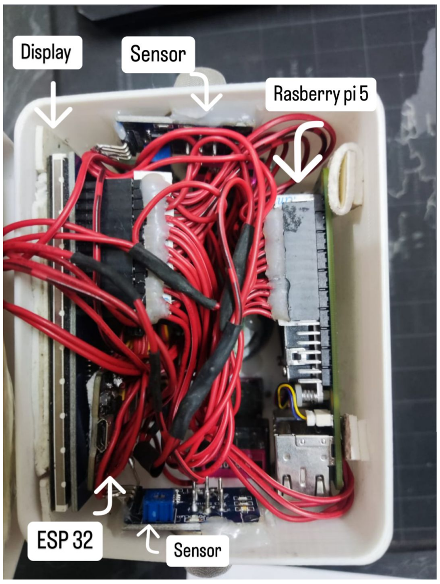


Figure 4.1: Architechture framework of TINY

The image illustrates a highly detailed robotic figure, which appears to be an educational robot equipped with various technological components.

4.2 Functional description of hardware components

- **Raspberry Pi (Brain):** A versatile single-board computer that serves as the brain of the robot. It can run programs, process data, and control other components. Function as the central processing unit, running the robot's operating system and educational applications. Using Raspberry Pi-5B for ample processing power and memory.

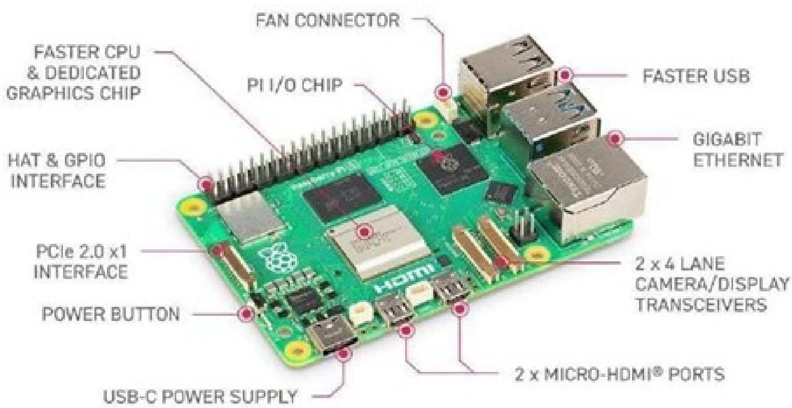


Figure 4.2: Raspberry Pi-5B details

- **ESP32 (Microcontroller):** Interfaces with sensors and actuators, handling low-level control tasks. Employee's a simpler programming environment suitable for beginners.

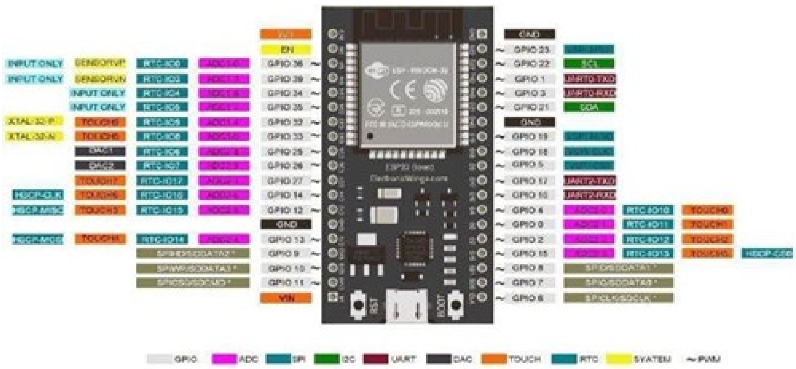


Figure 4.3: ESP32 Microcontroller details

- **Servo Motors (Movement):** Provide precise control over the robot's limbs or wheels for expressive movement and engaging interactions. Select a number of servos based on desired mobility (e.g., walking, head movement, arm gestures).

Figure 4.4: Servo Motors

- **Battery (Power Source):** Choose a rechargeable battery with appropriate capacity for extended use. Consider incorporating a power management system for efficient power consumption.

Figure 4.5: Battery (Power Source)

- **Touch Sensors:** Enhance interaction by detecting touches on the robot's body.

Figure 4.6: Touch Sensors

- **Microphone:** Facilitate voice interaction or environmental sound detection.

Figure 4.7: Microphone

- **Speaker:** Audio output for interaction and responses.

Figure 4.8: Hoco HC14 Bluetooth Speaker

4.3 Table of components list with cost

This table provides a concise overview of each component of TINY, including its specific role and how it integrates into the robot's system.

Component	**Price (BDT)**	**Specifications**
Raspberry Pi 5B (8GB)	15,000	8GB LPDDR4 SDRAM, Dual HDMI ports, USB 3.0
Raspberry Pi 5 Case with Cooling System	1,000	Custom case with integrated cooling fan
ESP8266 Wi-Fi module	300	802.11 b/g/n, 32-bit Tensilica Processor
4-inch LED display	4,000	800x480 resolution, HDMI interface
Switch	50	Push-button, SPDT
Battery Management System	500	Supports 1S/2S/3S Li-ion/LiPo
3D printed body	3,000	Custom design, PLA material
HDMI Converter	600	Micro HDMI to HDMI
Microphone for Raspberry Pi	500	Electret condenser, Omnidirectional
Sound Box	1,500	5W output, Bluetooth connect
Touch Sensor	150	Capacitive touch, TTP223
Humidity Sensor (DHT22)	200	Humidity Range: 0-100%
LiPo Battery (2200mAh)	1,200	2200mAh, 3.7V
1 Ohm Resistors	10	25C discharge rate
Servo Motors (4 units)	2,000	$\pm 5°$, SG90, 1.8kg/cm torque
Total	29510tk	

Table 4.1: Table of components list with cost

4.4 Economic Feasibility: TINY versus other robots for ASD support

Here are the estimated prices of the other robots, converted to Bangladeshi Taka (BDT) based on their approximate market value in USD.

Robot name	**Price (BDT)**
Milo	1,100,000 - 1,320,000 BDT
Moxie	164,890 BDT
NAO	825,000 - 990,000 BDT
QTrobot	825,000 - 990,000 BDT
Kiwi	132,000 - 165,000 BDT
Kasper Jibo	275,000 BDT 1,00,000 BDT.
Otisma	1,100,000 - 2,200,000 BDT
TINY	29510 BDT

Table 4.2: Costlist of robots for ASD support

The cost feasibility of TINY compared to commercially available robots such as Milo, Nao, and QTrobot highlights its affordability and potential for targeted functionality. This makes TINY an economically viable option for ASD support in resource-limited settings, where the high costs of international robots may be prohibitive. Its focus on essential features tailored for children with ASD ensures value without unnecessary expenses, enhancing accessibility for underserved communities.

4.5 Framework of software

TINY's software architecture integrates voice command processing, robot movement control, and sensor data collecting by arranging a complex interaction between Raspberry Pi and ESP. The operating system of choice, Raspberry Pi OS, offers a strong basis for the software modules' easy insertion and effective operation. TINY's software architecture epitomizes the synergy between innovation and inclusivity, harnessing the collective intelligence of Raspberry Pi and ESP to engender transformative learning experiences for children with ASD. Through the fusion of advanced speech recognition, NLP, and sensor technologies, TINY transcends the boundaries of conventional human-robot interaction, heralding a new era of personalized and immersive educational engagement. In the crucible of Raspberry Pi OS, TINY emerges as a beacon of accessibility and empowerment, illuminating the path towards a brighter future for children with ASD in Bangladesh and beyond.

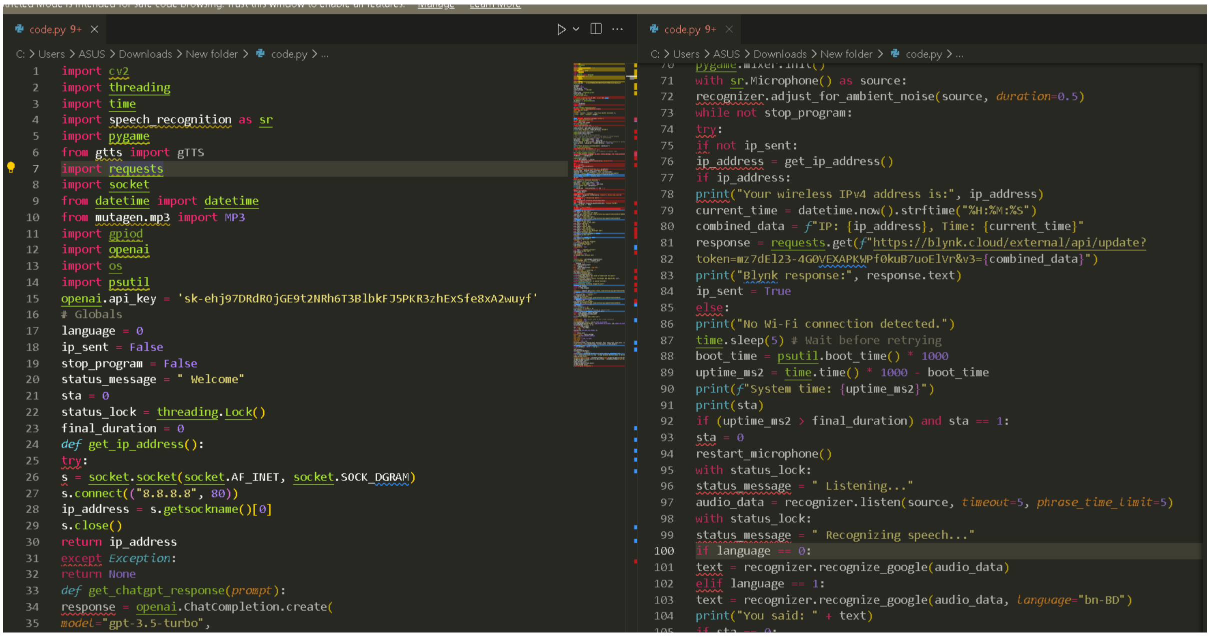


Figure 4.9: Software Coding of TINY Robot

4.6 Functional description of Software

- **Raspberry Pi for Voice Command Processing:** Raspberry Pi serves as the neural hub for interpreting and processing voice commands uttered by children interacting with TINY. Harnessing the computational process of Raspberry Pi, TINY's software employs cutting edge speech recognition algorithms, including Google's Speech- toText, to accurately transcribe spoken input. The essence of Natural Language Processing (NLP) permeates TINY's voice command processing, enabling it to decipher the nuances of human language and extract actionable commands. Through sophisticated dialogue management frameworks like Dialog flow, TINY engages in meaningful conversations with children, responding contextually to their queries, and fostering interactive learning experiences.

- **ESP for Robot Movement Control and Sensor Data Collection:** ESP emerges as the silent orchestrator behind TINY's physical movements and sensory perception. As the custodian of locomotion, ESP, whether powered by ESP8266 or ESP32, executes precise motor control commands, dictating TINY's graceful maneuvers and ensuring fluid interaction with its environment. Beyond motor control, ESP assumes the mantle of data aggregator, interfacing with an array of sensors strategically embedded within TINY's framework. Touch sensors, acting as tactile receptors, relay invaluable feedback regarding children's interactions, informing TINY's response mechanisms. Meanwhile, humidity sensors monitor ambient conditions, empowering TINY with environmental awareness and adaptability. This symbiotic relationship between ESP and sensors epitomizes TINY's holistic engagement with its surroundings, fostering enriched learning experiences.

- **Raspberry Pi OS for System Management:** At the nexus of TINY's software ecosystem resides Raspberry Pi OS, a veritable sanctuary for system management and orchestration. Embracing a spectrum of libraries and software tools, Raspberry Pi OS forms the bedrock upon which TINY's software components converge and coalesce. Within this fertile milieu, voice command processing, robot movement control, and sensor data collection seamlessly intertwine, facilitated by the OS's robust multitasking capabilities. Realizing the vision of an adaptable and responsive educational companion, Raspberry Pi OS empowers TINY with the computational agility and resource optimization necessary to navigate the dynamic landscape of child-robot interaction.

- **Integration and Interoperability:** TINY's software architecture epitomizes harmony through integration, seamlessly fusing disparate components into a cohesive whole. Voice commands, transmuted into actionable directives by Raspberry Pi, trigger a cascade of responses orchestrated by ESP, culminating in fluid movements and adaptive behaviors. Concurrently, sensor data, harvested by ESP from the ambient environment, imbues TINY with environmental acuity, guiding its interactions and responses. This intricate dance of software and hardware, facilitated by Raspberry Pi OS, underscores TINY's efficacy as a versatile and responsive educational tool for children with ASD.

- **Programming Languages:** Widely used for Raspberry Pi programming due to its simplicity and extensive libraries.

Chapter 5

Overview of ASD

5.1 Classifications of ASD

Autism, also referred to as autism spectrum disorder (ASD), is a complex neurological condition that affects the development of the brain. ASD is not a single condition but a group of disorders that are all connected.

- It is most commonly connected to difficulties with social relationships, ineffective verbal or nonverbal communication, and behavioral issues.
- Some of these issues include repeated actions and narrowly focused interests. It is predominantly seen in men, who are affected four times more than women.
- Cognitive and Functional Variations:Significant impairments in communication and daily living.
- ASD affects multiple aspects of daily life, including social, educational, and occupational functioning.
- ASD symptoms and their severity vary widely, forming a spectrum of conditions.
- Repeated actions and routines are characteristic traits of individuals with ASD.
- Individuals may exhibit unusual or challenging behaviors.
- Individuals with ASD often struggle with forming and maintaining social relationships.
- Autism, or ASD, is a complex neurological disorder that affects brain development.
- Verbal and nonverbal communication difficulties are common in ASD.

Table:The 5 main types of (ASD)

Type	Characteristics	Severity	Diagnosis
Classic Autism (Autistic Disorder)	Significant challenges in social interactions, communication, and a high level of repetitive behaviors and restricted interests.	Often considered the most severe form on the spectrum.	Typically diagnosed in early childhood.
Asperger Syndrome	Difficulties in social interactions and repetitive behaviors, but without significant delays in language or cognitive development.	Considered a milder form of ASD.	Often diagnosed later in childhood, sometimes even in adolescence or adulthood.
Pervasive Developmental Disorder - Not Otherwise Specified (PDD-NOS)	Individuals exhibit some but not all of the characteristics of classic autism or Asperger syndrome.	Varies widely, from mild to severe.	Typically used when the full criteria for classic autism or Asperger syndrome are not met.
Childhood Disintegrative Disorder (CDD)	Normal development for at least the first two years followed by a significant loss of previously acquired skills (language, social, and motor skills).	Considered a rare and severe form of ASD.	Typically occurs between the ages of 3 and 4.
Rett Syndrome	Normal early development followed by a loss of purposeful use of the hands, slowed head growth, and intellectual disability.	Severe, primarily affecting girls.	Often diagnosed between 6 months and 2 years of age.

Table 5.1: Characteristics, severity, and diagnosis of different types of Autism Spectrum Disorder (ASD).

5.2 List of ASD center in Dhaka

Some of the name of autism school and centers located in Dhaka.

Table: List of ASD center in Dhaka

ASD Center Name	Location	About
Bangladesh ABA Centre for Autism	Uttara	Serving since 2008. Offers a range of services including diagnostic evaluations, Applied Behavior Analysis (ABA) therapy, speech and language therapy, sensory integration therapy, and vocational training.
CS Care	Mirpur	Established in 2012, provides speech and language therapy, occupational therapy, and physiotherapy.
Angel Care Foundation	Tajmahal Road, Mohammadpur	Found in 2009. Welfare foundation for children with intellectual disabilities or other neurodevelopmental disabilities.
Banasree D. S. L School	Banasree	For children with disabilities: autistic, hearing impaired, Down syndrome, delayed speech, hyperactive.
Bangladesh Therapy & Rehabilitation Foundation (BTRF)	Shekhertek, Mohammadpur	Provides quality intervention and rehabilitation services for children with autism and other disabilities.
Basundhara Special Children Foundation (BSCF)	Hasnabad, South Keranigonj	Located in Bashundhara Riverview Project, this foundation provides education and therapy for children with autism and other disabilities.
Blessing Child Special School (BCSS)	Aftabnagar, Badda	Formed in 2018, this school offers specialized education and therapy for children with autism and other disabilities.
Child Education Center (CEC)	Zigatola	A treatment-based home and school for the rehabilitation of children with autism.
CHILD Foundation	Gulshan 2	Established in 2016. This nonprofit organization provides services and advocacy for individuals with special needs, including autism.
Angels of Heaven	Uttar Adabar	Preschool and autism care center with general medical checkups.
Autism Welfare Foundation	Shamlapur, Keraniganj	Established in 2004. Its aim is to educate children to perform to their maximum potential and create awareness in society.

Table 5.2: List of ASD center in Dhaka

5.3 The Blue Bird ASD center

For our survey, we visited a school located in Baridhara named Blue Bird Special School, an organization that specializes in teaching and treating kids with autism spectrum disorder (ASD). Established on June 6, 2016, the center is a non-profit private institution dedicated to meeting the various needs of kids with autism spectrum disorders.

Figure 5.1: Blue Bird Foundation ASD center

The purpose of the visit was to gain a firsthand understanding of the experiences of children with Autism Spectrum Disorder (ASD) and the supportive environment provided by Blue Bird Special School. During the visit, we acquired significant insights into the struggles of ASD children.

Figure 5.2: Classroom of Blue Bird ASD center

Blue Bird Special School accommodates approximately 50 students, each receiving individualized attention with a teacher-student ratio of 1:1. The school's principal, Ms. Shahana Karim, provided an overview of the center's approach to supporting children with ASD. As every child is unique and their problems are also different so each of them are provided with different therapies. During our discussions, we gained valuable insights into the diverse needs and challenges faced by children with ASD. She emphasized the importance of individualized education plans tailored to each child's strengths, needs, and preferences. Ms. Karim also highlighted the significance of early intervention and the role of specialized therapies in promoting skill development and independence among ASD children. Following the discussions, Ms. Karim kindly led us on a tour of the classrooms, where we observed firsthand the learning activities and interactions taking place.

The classrooms were divided into three types, each catering to children at different levels of functioning. In each classroom, we witnessed dedicated teachers engaging students in a variety of educational and therapeutic activities. The atmosphere was nurturing and supportive, with a focus on promoting social interaction, communication skills, and sensory integration. Teachers employed various strategies and interventions to meet the unique needs of each child, fostering a sense of belonging and empowerment.

5.4 Different World Foundation

Different World Foundation (DWF) ASD center, established in Dhaka in 2010, is dedicated to providing comprehensive support for children with Autism Spectrum Disorder (ASD) and related neurodevelopmental challenges. Since its inception, DWF has aimed to improve the quality of life for children with ASD through tailored therapeutic interventions and educational programs. The center offers a wide range of services, including Applied Behavior Analysis (ABA), speech and language therapy, occupational therapy, sensory integration therapy, and social skills development programs. DWF emphasizes a family-centered approach, providing training and counseling for parents to equip them with strategies for supporting their children at home. The foundation is staffed by a team of skilled professionals committed to fostering an inclusive and supportive environment, helping each child achieve greater independence, communication, and social engagement. Over the years, DWF has become a respected resource in Dhaka, helping many families navigate the complexities of ASD with compassion and expertise.

Figure 5.3: Classroom of Diffrent World Foundation

During our visit to the Different World Foundation ASD Center, we were impressed by the center's commitment to supporting children with Autism Spectrum Disorder (ASD) and their families. The facility features well-equipped classrooms designed for individualized learning, therapeutic rooms for speech and occupational therapy, and a calming sensory room to help children with emotional regulation. We observed engaging interactive sessions that promote social skills and witnessed dedicated therapists working closely with the children. The center also provides valuable resources for families, including support groups and educational workshops. The Different World Foundation ASD Center plays a crucial role in the lives of children with ASD and their families. By providing specialized education, therapeutic interventions, and a supportive community, the center fosters growth and development while helping families navigate the challenges associated with autism.Overall, the visit highlighted the profound impact the Different World Foundation has in fostering a nurturing environment that empowers children with ASD and enhances their quality of life. The survey report explores the potential impact and challenges of

Figure 5.4: Guardian being surveyed about the use of robotic technology for ASD therapy

using the TINY tutor robot as an educational tool for children with Autism Spectrum Disorder (ASD) in Bangladesh. The robot is designed to provide personalized learning experiences and social interaction opportunities, supporting their educational, social, and emotional development. Most respondents expressed positive attitudes towards the use of the robot, but some expressed concerns about its limitations, accessibility, affordability, and technical support. The ASD center emphasizes the importance of customizing the robot to suit the unique needs and preferences of children with ASD. Our robot TINY is suitable for high functioning ASD children as they may benefit from interaction with educational robots due to their strong cognitive abilities. Interest in technology and structured interactions may also make robots more appealing.

5.5 Sectors focused for the treatment of ASD

- **Behavior Solutions-** Different World Foundation and Blue Bird Special School recognizes the importance of addressing behavioral challenges that may arise in children with ASD. Through evidence-based interventions and individualized support plans, the school aims to help students develop appropriate behaviors and coping strategies.

- **Speech and Communication-** Many children with ASD experience difficulties in speech and communication, ranging from delays in language development to challenges in social communication. Provides targeted speech therapy and communication support to help students improve their verbal and nonverbal communication skills.

- **Social Skills-** Social interaction can be a significant challenge for children with ASD, who may struggle to understand social cues and engage in reciprocal communication. The school focuses on teaching social skills, fostering peer interactions, and promoting friendship-building among students.

- **Sensory Solutions-** Sensory sensitivities are common among individuals with ASD, who may experience heightened or diminished responses to sensory stimuli. Those ASD centers offers sensory integration therapy and accommodations to help students regulate their sensory experiences and participate fully in their learning environment.

- **Executive Functions and Motor Skills-** In addition to addressing sensory sensitivities, recognizes the importance of supporting motor development and coordination in children with ASD. Many children with ASD may initially struggle with fine and gross motor skills, including difficulties with hand-eye coordination, grasping objects, and performing coordinated movements with their hands and legs.

- **Through targeted sensory-** Different World Foundation and Blue Bird Special School utilizes motor integration therapy and occupational therapy interventions to support children with Autism Spectrum Disorder (ASD) in developing essential motor skills. These therapies are designed to enhance proprioception, balance, coordination, and motor planning, providing children with tools to improve control and confidence in their movements. By addressing motor-related challenges, the school aims to foster greater independence and proficiency in physical activities, enabling students to engage more effectively with their environment.

- **Mental Health and Anxiety-** Children with ASD are at an increased risk of experiencing mental health challenges, including anxiety and depression. Those ASD centers prioritizes mental health support, offering counseling services and strategies for managing anxiety and promoting emotional well-being.

- **Self-Care-** Independence in self-care tasks, such as personal hygiene and daily living skills, is a crucial aspect of ASD education. The school focuses on teaching self-care. skills and fostering independence to help students gain confidence and autonomy in their daily lives.

- **Dealing with Transitions-** Transitions can be particularly challenging for children with ASD, who may struggle with changes in routines or environments. Those ASD centers provides support and strategies for managing transitions effectively, helping students navigate change with greater ease and confidence.

Chapter 6

Dataset

6.1 About questionnaire

The objective of the survey was to gather insights from teachers and guardians of ASD children regarding the use of robots in ASD therapy in Bangladesh. The key survey questions were:

- **Awareness of robotic technology for ASD-** To see how familiar teachers and guardians of ASD children are with the existence and applications of robots designed to assist with ASD therapy. Understanding the level of awareness helps identify gaps in knowledge and the need for educational campaigns to inform stakeholders about technological advancements.

- **Experience with ASD robots in Bangladesh-** This examines whether teachers and guardians have encountered or used robots specifically designed for ASD therapy within Bangladesh. This information can provide insights into the penetration and practical application of robotic technology in local ASD therapy settings

- **Perceived benefits-** This point focuses on understanding what respondents believe are the potential advantages of using robots for ASD therapy. It categorizes the expected benefits, such as reducing anxiety levels, enhancing interest in educational activities, improving social and communication skills, and other perceived positive outcomes.

- **Decision-making factors-** To identify the key factors that influence the decision to adopt and use robots for ASD therapy. It includes considerations such as the proven effectiveness of robots from research studies, support from government or educational institutions, availability of funding and resources, and other relevant factors.

- **Desired features-** Outlines the specific features that respondents believe should be included in robots designed for children with ASD in Bangladesh. It highlights the importance of features like the ability to modify procedures for individual requirements, communication abilities, speaking the local language (Bangla), and engaging the children through entertainment.

- **Implementation challenges-** The potential obstacles and challenges that might arise when implementing the use of robots for ASD therapy. It considers issues such as financial constraints, technical support and maintenance, resistance to new technology, and other practical challenges that could affect successful deployment.

- **Additional features or modifications-** Respondents' recommendations for any further features or adjustments that would improve robots' ability to meet the requirements of kids with ASD. It aims to collect ideas for improving and tailoring the technology to better suit the specific requirements of the target population.

6.2 Survey results

In this section, we present the findings from our survey.

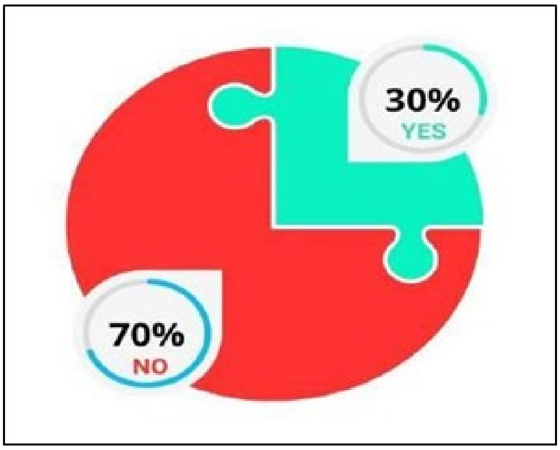


Figure 6.1: Awareness of robot developed for communicating with ASD children

This figure illustrates the awareness level among respondents regarding the existence of robots developed specifically to communicate with children with Autism Spectrum Disorder (ASD). The data is presented in a pie chart format, which shows a minority of respondents (parcentage of 30) are aware that such robots exist and a majority of respondents (parcentage of 70) are not aware of the existence of these robots.This indicates that there is a significant lack of awareness among the surveyed population about the technological advancements available for ASD therapy.

Figure 6.2: Perceived Benefits of Robots for Children with Autism Spectrum Disorder (ASD) in Bangladesh

This figure summarizes the perceived benefits that robots can provide to children with ASD as identified by the respondents. The chart demonstrates that the most commonly perceived benefits are related to anxiety reduction and increased engagement in education, while fewer respondents focus on social and communication skills improvement.

Figure 6.3: Factors influencing the decision to use robots for ASD children in Bangladesh

This figure presents a bar chart depicting the various factors that influence the decision to utilize robots for children with Autism Spectrum Disorder (ASD) in Bangladesh. The chart identifies the following key factors:

- **Proven effectiveness from research studies:** Highlighted by a substantial number of respondents as a critical factor, indicating the importance of evidence-based validation for the adoption of robotic technology.

- **Support from government or educational institutes:** This factor is emphasized by many respondents, showcasing the need for institutional backing and endorsement.

- **Availability of support, funding, or resources from government or educational institutions:** A significant number of respondents consider this crucial, indicating that financial and resource support is essential for the implementation of robotic solutions.

- **Others:** A smaller number of responses fall into this category, covering additional unspecified factors.

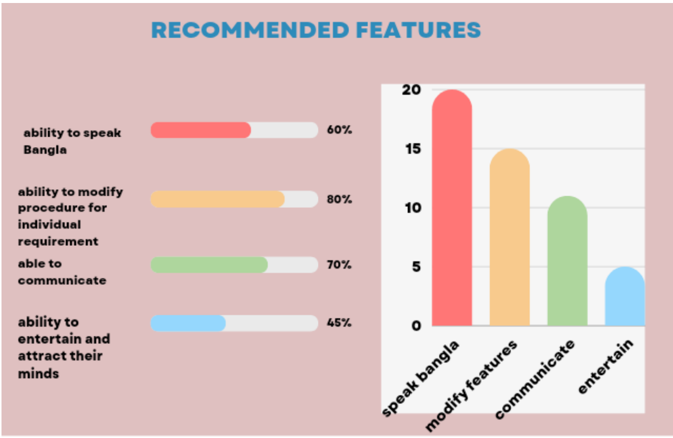


Figure 6.4: Recommended features for a robot designed for ASD children in Bangladesh

This figure displays a combination of a bar chart and a percentage breakdown of the recommended features for robots designed to assist ASD children in Bangladesh. The recommended features are:

- **Ability to modify procedure for individual requirements (percentage of 80):** The most highly recommended feature is the ability for robots to adapt procedures to meet individual needs.

- **Able to communicate (percentage of 70):** A substantial percentage of respondents prioritize the robot's ability to communicate effectively.

- **Ability to speak Bangla (percentage of 60):** More than half of the respondents highlight the importance of the robot being able to speak the local language, Bangla.

- **Ability to entertain and attract their minds (percentage of 45):** Less critical but still important is the robot's ability to entertain and engage the children.

This figure illustrates the importance of customization, communication, and cultural relevance in the design of robots for ASD therapy.

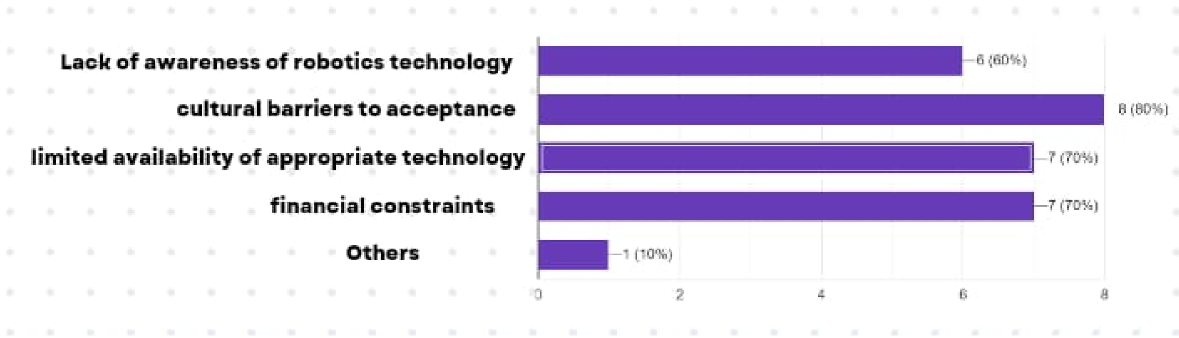


Figure 6.5: Potential Challenges in Implementing Robots for Children with Autism in Bangladesh

The above figure shows the challenges that may arise if robots are implemented on the autistic children. These include- lack of awareness among people about robotics technology and the number is huge, cultural barriers, very limited accessibility to the technology needed for this purpose and finally and most importantly financial constraints as huge budget is required to implement this successfully.

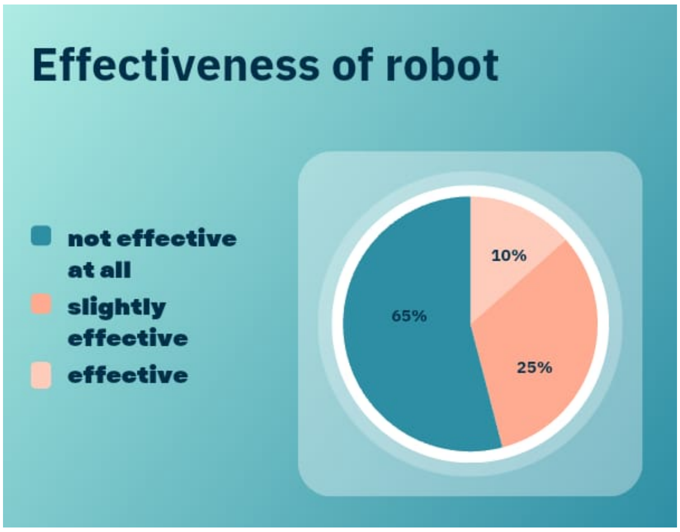


Figure 6.6: The effectiveness of robots in improving autistic children's social skills

This above figure shows how a robot might be effective if any at all in this area. As this is a sensitive issue, so most of them think that a robot may not be as useful for these type of children and are not capable of handling these children with special needs. Still some are positive towards this initiative and hope for the betterment in the future.

Chapter 7

Discussion

One of the key objectives of TINY is to facilitate the learning process for ASD children by providing them with a consistent and patient learning companion. Traditional educational environments can be challenging for children with ASD due to sensory sensitivities and difficulties in social interaction. TINY addresses these challenges by offering a controlled, predictable, and non-judgmental environment where children can learn at their own pace. Research has shown that children with ASD can significantly benefit from repetitive, structured learning experiences, and TINY excels in delivering these. The robot can introduce, reinforce, and practice various educational concepts, such as numbers, colors, shapes, and social skills, in a way that is both engaging and accessible. Moreover, TINY's ability to provide immediate and appropriate feedback helps to reinforce positive learning behaviors and build confidence in the children. While TINY offers significant benefits, the project also faces several challenges. Ensuring the robot's adaptability to the wide range of ASD symptoms and individual learning needs is complex and requires ongoing research and development. Additionally, integrating TINY into existing educational frameworks and gaining acceptance from educators and parents are critical factors that will influence the robot's long-term success.

Future developments may include expanding TINY's capabilities to address more diverse educational needs, incorporating advanced artificial intelligence for even more personalized learning experiences, and developing cloud-based platforms for real-time data analysis and progress tracking.

How TINY Stands Out

TINY is unique in its affordability, localization, and focus on the Bangladeshi context. While the NAO robot and other systems demonstrate effectiveness in ASD therapy, their high costs and lack of regional adaptability limit their feasibility in countries like Bangladesh. TINY's incorporation of Bangla voice interaction,low-cost components, and experimental validation with local children and guardians makes it a promising tool to address ASD challenges in resource-constrained settings.

7.1 Assessment of Extended Impacts on Child-Robot Interaction

The participants' movements of their hands and arms, as well as how they looked at the robot, the game, and any other individuals present, were all noted. The data revealed that there was no appreciable decline in the kids' interest in or involvement with the robot or game. Conversely, there was a change in focus toward giving the parents of the children greater consideration and involvement. Furthermore, relatively little research has been done on these three problems. There isn't any concrete research on how well robots train Children with ASD (CwASD) in place of qualified instructors or trainers. We anticipate that future investigators wishing to focus on different aspects of robot-assisted CwASD training would find this material useful as a guide.

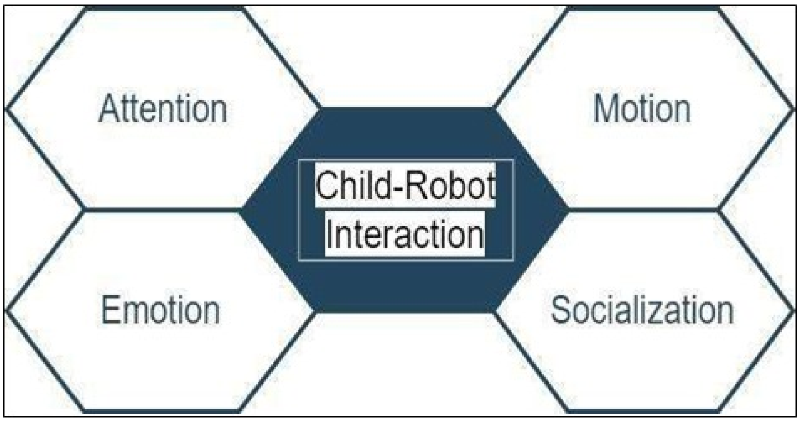


Figure 7.1: Child–Robot Interaction (CRI) aspects

TINY, an educational robot for Bangladeshi children, has the potential to make learning engaging and accessible. It can answer questions in Bangla and support the local school curriculum. However, it needs to understand a wider range of local dialects and regularly update its content. Enhancing interactivity with games and culturally relevant material could make learning more enjoyable. To achieve widespread adoption, it should be affordable, ensure user privacy, and be designed to be attractive and engaging. The project required expertise in technology, education, linguistics, and a deep understanding of children's learning experiences. The objective was to create an intriguing robot that was affordable and accessible to a wide range of children.

7.2 Experimental design and user data

The project is dedicated to enhancing the interaction model of TINY, a robot designed to engage children with autism spectrum disorder (ASD) in Bangladesh, by following an iterative development process. During the pilot testing phase, sessions were conducted with a small group of children (10-15) aged 6 to 10, all diagnosed with high-functioning autism, recruited from an ASD therapy center in Dhaka, Bangladesh. The aim was to evaluate the robot's usability and effectiveness. Parents and educators of the children were thoroughly informed about the study's purpose, and formal consent was obtained for their participation.

To ensure that the testing environment was familiar and comfortable for the children, reducing potential anxiety or environmental distractions, the experiment took place in the participants' usual guidance or counseling classroom. Experts consulted for the study emphasized that such a familiar setting would help maintain natural responses. Additionally, two cameras were strategically positioned in different locations to capture the procedure, facilitating a comprehensive review of the interactions and outcomes. The robot was set up on the classroom desk sitting to the left of the robot, a research assistant helped handle unforeseen situations. A counselor escorted the child to the front of the robot as soon as the participant entered the classroom. By starting up a friendly discussion, the counselor helped the child feel less odd and more at ease in the new surroundings. Only when it was determined that the child's circumstances and emotions were appropriate for the trial was the experiment carried out. To find out if the autistic child's behavior changed before and after engaging with the robot, an interview with the adviser of the child was done at the conclusion of each trial phase. The robot interaction involves greetings and self-introductions, aiming to understand children's participation in learning tasks. Physical instructions are included to assess children's participation in physical actions. The robot then leads children in singing, focusing on their development and involvement in verbal interaction [18]. Feedback from participants, caregivers, and educators is used to identify strengths and weaknesses. The model is then refined and enhanced through an iterative development cycle, collaborating with interdisciplinary teams to ensure cultural and linguistic relevance. The study will evaluate the impact of TINY on social communication skills, engagement, and learning outcomes of the children. The intervention will be delivered over a period of 1 week, with regular sessions lasting 1 hour each for interaction and engagement. User-centered design principles are applied throughout the process, prioritizing the needs, preferences, and feedback of children, caregivers, and educators. User data is collected from 8 children diagnosed with ASD in Bangladesh.
The participants were aged 5-6, 7-8, and 9-10 years old.

Serial No.	Age Range
1	5-6 years
2	7-8 years
3	9-10 years
4	10-12 years

Table 7.1: Age Range of ASD Children

Serial No.	Interaction Criteria
1	Attention
2	Eye Contact
3	Physical Interaction
4	Conversational Content

Table 7.2: Criteria for the interaction of ASD children with TINY

TINY was used to facilitate communication initiation and response behaviors, leading to improved verbal and non-verbal communication. TINY also elicited positive emotional responses from many participants. Parents/caregivers reported positive experiences with TINY, noticing improvements in their children's engagement and communication skills. However, some parents faced challenges related to sensory sensitivities or attention difficulties. Parents/caregivers suggested potential enhancements to TINY's design or programming to better meet the needs of children with ASD. Overall, the interaction study's findings point to TINY's potential use as a teaching and therapeutic aid for Bangladeshi children with ASD diagnoses. In a variety of cultural and language contexts, TINY has the potential to improve the socialization and educational experiences of children with ASD by promoting engagement, the development of communication skills, and positive emotional reactions. In order to maximize TINY's design and programming for optimum efficacy and usability in meeting the needs of children with ASD and their families, more research and development initiatives are being conducted.

7.3 Result and Analysis

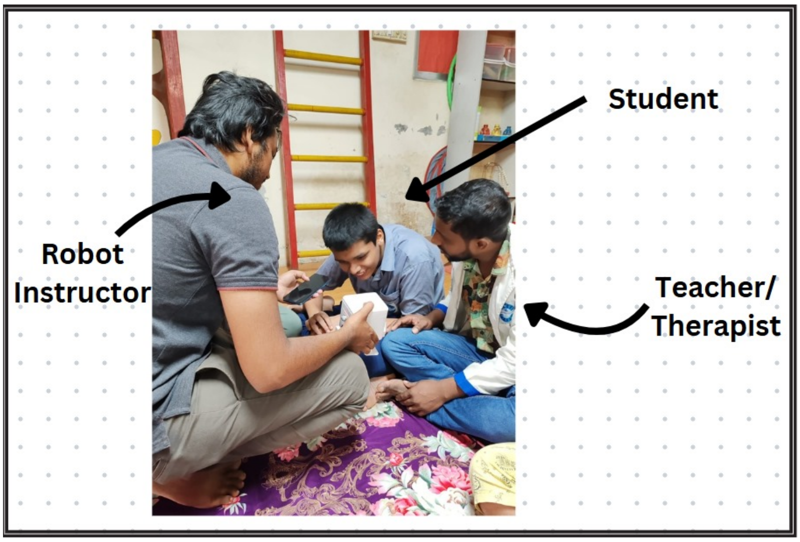
In recent years, there has been an increase in the use of robotics technology in education and intervention for children with autism spectrum disorder (ASD). To fully reap the benefits of robot assisted treatment, a number of research difficulties and hurdles still need to be resolved. Children diagnosed with Autism Spectrum Disorder (ASD) exhibit constrained, repetitive patterns of behavior, such as stereotyped or repetitive motor movements or routine involvement, and functional impairment in social interactions and communication across settings. They struggle to read facial expressions, maintain eye contact, communicate their own emotions, and comprehend those of others. Owing to these constraints, medical and educational personnel usually find it difficult to inspire and include children with ASD in therapy and academic endeavors. It is crucial to engage in a variety of social, recreational, educational, and therapeutic activities in order to get the information required for intellectual and social development.

The interaction study with children diagnosed with autism spectrum disorder (ASD) in Bangladesh found that TINY, a technology, facilitated engagement, communication skills development, and positive emotional responses. Some children showed active participation, while others displayed passive or limited engagement. The study suggests that TINY's design and programming may influence the level and nature of engagement observed in children with ASD. TINY's interactive features and responsive feedback have contributed to the observed improvements in communication skills. Positive emotional responses were observed in many participants, indicating its potential as a therapeutic tool for promoting socialization and emotional well-being. Parents and caregivers reported positive experiences with TINY, but some reported challenges related to sensory sensitivities or attention difficulties. Demographic data revealed potential age and gender differences in engagement levels and interaction patterns. For example, smaller children showed more engagement than older children.

Figure 7.2: Group Photo of ASD Students, Educators, robot TINY

7.4 The advantages of interacting with a robot for those with (ASD) Autism Spectrum Disorders

The two primary criteria for autism are repetitive behaviors and limited interests on the one hand, and poor social interaction and communication on the other. Both symptoms can be addressed by the robot: its application with autistic individuals is often focused on enhancing communication abilities and decreasing repetitive habits. As a result, therapies target specific behaviors like learning acceptable actions and decreasing maladaptive behaviors (such as anxiety and stereotyped behaviors) in addition to communication and social interaction issues. Depending on the goal, three different kinds of interventions can be identified: robots can encourage social interaction and communication, which can help people learn particular behaviors, like recognizing emotions, and they can also lessen the prevalence of behaviors that are considered maladaptive, like anxiety and repetitive behaviors.



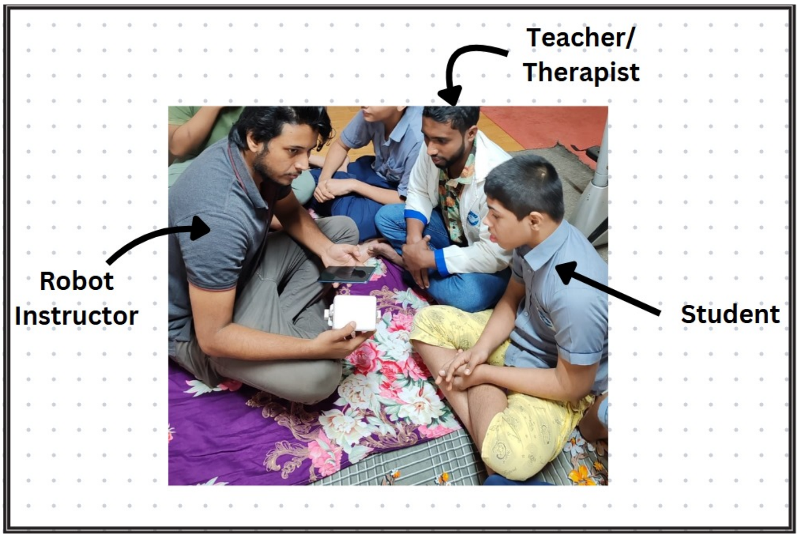


Figure 7.3: Interaction between an ASD student and robot TINY

Table: Benefits of robots in fostering communication and social interaction in individuals with ASD:

Student	**Age (Years)**	**Syndrome**	**Section (Social Behaviors)**	**Effect of Robot**	**Duration of Robot Intervention (minutes)**
Student 1	4	Classic Autism	Touch	Positive	10
Student 2	4	CDD	Eye-gaze	Negative	5
Student 3	6	PDD	Communication (facial expression)	Positive	10-15
Student 4	7	Asperger	Eye contact	Negative	5
Student 5	9	Asperger	Interaction initiation, Communication (verbal)	Positive	20
Student 6	11	Rett Syndrome	Engagement time	Negative	5
Student 7	11	Classic Autism	Spontaneous touch	Negative	5
Student 8	12	Asperger	Communication (verbal)	Positive	10
Student 9	13	PDD	Eye contact	Negative	5
Student 10	16	Asperger	Communication (facial expression and verbal)	Positive	15
Student 11	5	Classic Autism	Touch	Positive	8
Student 12	6	PDD	Eye-gaze	Negative	5
Student 13	8	Asperger	Interaction initiation	Positive	12
Student 14	8	Rett Syndrome	Communication (verbal)	Negative	5
Student 15	10	CDD	Engagement time	Positive	10
Student 16	10	Classic Autism	Spontaneous touch	Negative	5
Student 17	11	Asperger	Communication (facial expression)	Positive	10
Student 18	12	PDD	Eye contact	Negative	8
Student 19	14	Classic Autism	Interaction initiation	Positive	10
Student 20	14	Asperger	Communication (facial expression and verbal)	Positive	15

Table 7.3: Benefits of robots in fostering communication and social interaction in individuals with ASD

7.5 Post-Survey Analysis

Table: The table of Interest and Social Interaction of a Child with TINY:

Question Categories	Positive response	Negative response
Enjoyed Learning	2	6
Comfortable Talking to TINY	1	7
Would Like to Talk Again	3	5
Thinks TINY as a Friend	2	6

Table 7.4: The table of Interest and Social Interaction of a Child with TINY

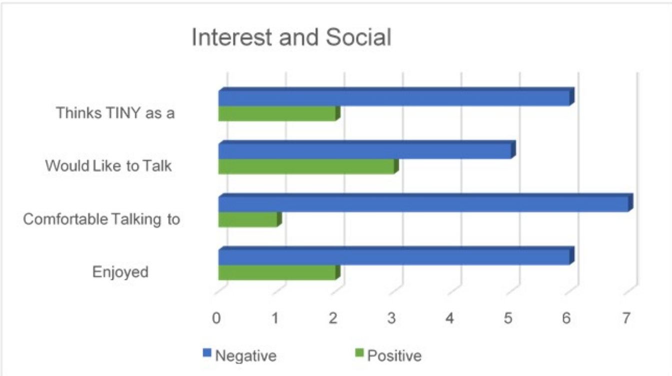


Figure 7.4: Interest and Social Interaction of a Child with TINY

The result of Follow-Up Questions to Guardians:

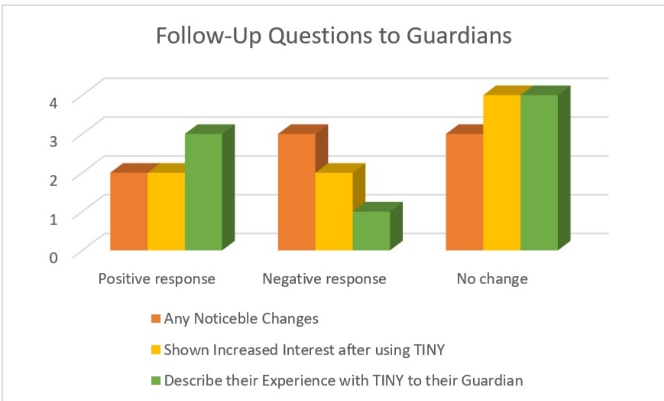


Figure 7.5: Follow-Up Questions to Guardians

7.6 Feature Comparison: TINY vs. Leading Educational and Assistive Robots for Children

The comparative feature analysis of TINY and other leading educational robots, such as Milo, Moxie, Kasper, Otisma, Jibo, Kiwi, NAO, and QTrobot, highlights the strengths and limitations of each. While TINY is designed specifically for children with Autism Spectrum Disorder (ASD), focusing on affordable, tailored therapeutic interaction, other robots like Milo and QTrobot also provide specialized therapy for ASD but at significantly higher costs. Robots like Jibo and Kiwi, while offering general social interaction and educational engagement, lack the ASD-specific features that make TINY and its counterparts more suited for therapeutic settings. NAO and Moxie, known for their broader educational applications, feature advanced AI but come with a steep price tag, making them less accessible for all users. The analysis reveals that TINY offers a cost-effective solution with a focus on essential features, while more expensive robots provide more advanced functionalities but may not be practical in resource-constrained environments.

Overall, TINY provides a focused, affordable solution for children with ASD, while other robots may offer a broader range of capabilities but are generally less accessible due to higher costs or lack of targeted features for ASD-specific therapy..

Robot name	**Primary**	**Features**
TINY	Designed for children with Autism Spectrum Disorder (ASD) to improve interaction and learning through tailored educational models.	Customized interaction models for ASD therapy. Usability-focused design for high-functioning autistic children. Cost-effective and targeted for low-resource settings.
Milo	Supports social and emotional learning for ASD children.	Advanced facial expressions and conversational capabilities. Tracks emotional responses in children. Highly interactive and curriculum-integrated software.
Moxie	General emotional and social learning for children.	AI-powered empathy training. Daily social-emotional lessons. Generalized interaction not specifically tailored for ASD.
Kasper	Interactive learning for children with ASD.	Simplified design and interaction style. Focus on turn-taking, communication, and basic social skills. Designed for controlled, therapy-based environments.
Otisma (Tesla Optimus)	A versatile humanoid robot for various industrial and personal tasks (not ASD-specific).	High mobility and operational autonomy. Capable of performing physical labor and household tasks. Expensive and not tailored for therapeutic applications.
Jibo	General-purpose social robot	Limited conversational and social interaction capabilities. Designed for family and home use rather than therapy. No specific features for ASD therapy.
Kiwi	Educational robot focused on STEAM learning.	Engages children in programming and interactive learning. Not ASD-specific but promotes cognitive development. Primarily used in educational environments.
NAO	Multi-functional humanoid robot used in research, education, and therapy.	Robust programming for ASD therapy and education. Expressive and interactive communication. Customizable software for diverse applications.
QTrobot	Specifically designed for ASD therapy.	Simplified and expressive design to engage ASD children. Preloaded with autism therapy programs. Easy for therapists and caregivers to operate.

Table 7.5: Comparative Feature Analysis of TINY and Leading Educational Robots

Chapter 8

Future Work and Conclusion

In the field of educational robotics, it showcases a promising avenue to foster children's development, especially with the introduction of robots like TINY. It underscores the ability for these robots to engage children actively in educational activities specially children with special cases, such as learning difficulty. TINY with its foundation in teaching, inspiring, epitomizes the progressing landscape of educational tools that focuses on enhancing the interest in reading and developing skills at an early age. Tiny is a low-cost interaction robot that was created as an accessible and reasonably priced way to help Bangladeshi children who suffer from autism spectrum disorder (ASD). This revolutionary gadget combines interactive elements and Bangla language support to meet the unique requirements of youngsters in the area who have ASD. The robot's versatile settings and user friendly interface are intended to support social interaction, communication, and learning experiences that are customized to meet the specific needs of every child. This robot aims to close the accessibility gap to assistive technologies for Bangladeshi children with ASD, thereby promoting inclusion and improving their quality of life. It does this by utilizing open-source platforms and low-cost technology. It is essential to include augmented reality characteristics like multisensory integration, customization, and immersive experiences. TINY is developed to help therapists during therapy sessions with children who have autism. In general, the field of robot-assisted therapy holds great potential for the use of intelligent social robots, particularly in helping children with ASD meet their educational and therapeutic goals, such as developing their social and emotional skills, their ability to communicate and interact with others, their cognitive abilities, their motor skills, and their sensory perception. We hope that the difficulties will shortly be resolved by skilled interdisciplinary cooperation.

Chapter 9

Appendix

Questionnaire

Learning and Cognitive Skills:

1. Can you count with me?
2. What sound does a cat make?

Emotions and Social Skills:

3. What makes you feel happy?
4. How do you feel right now?
5. Can you blink your eyes?
6. What can you do if a friend is sad?
7. What do you do when you feel upset?

Communication and Social Interaction:

8. What do you say if someone gives you a gift?
9. How can you ask for help?
10. What do you say when you meet someone new?
11. Can you tell me about something fun you did today?
12. What do you say if someone says hello?

Extra Question:

- Are you happy today?
- What makes you smile?
- Do you feel calm now?
- What did you do today?
- Do you like playing or drawing?
- Is it time to rest now?
- Can you count to five with me?
- What color is your shirt?
- Do you know the name of this animal?
- Do you want to play a game or listen to a story
- Which one do you like—blue or red
- Should I walk or raise my hand?
- Do you like this sound?
- Is the light too bright for you?
- Do you like to watch the stars?
- Let's walk together! Can you follow me?
- Can you raise your hand when I say go?
- What's your favorite toy?
- Do you feel safe here?
- Shall we take deep breaths together?

- Would you like to sit and relax?”
- How can we make a friend feel happy?
- What should you do if you feel sad?

* Survey Question Form

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