

B.Sc. in Computer Science and Engineering Thesis

# **The Study of an Effective Communication Tool to Assist the Children and Young Adults with Autism**

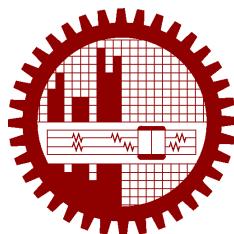
Submitted by

Taufiqun Nur Farid  
1705049

Md. Shafaet Zaman  
1705086

Supervised by

Dr. Mahmuda Naznin  
Professor  
Department of Computer Science and Engineering  
Bangladesh University of Engineering and Technology



**Department of Computer Science and Engineering  
Bangladesh University of Engineering and Technology**

Dhaka, Bangladesh

May 2023

## **CANDIDATES' DECLARATION**

This is to certify that the work presented in this thesis, titled, "The Study of an Effective Communication Tool to Assist the Children and Young Adults with Autism", is the outcome of the investigation and research carried out by us under the supervision of Dr. Mahmuda Naznin Professor

Department of Computer Science and Engineering  
Bangladesh University of Engineering and Technology

It is also declared that neither this thesis nor any part thereof has been submitted anywhere else for the award of any degree, diploma or other qualifications.

---

Taufiqun Nur Farid  
1705049

---

Md. Shafaet Zaman  
1705086

## **ACKNOWLEDGEMENT**

We are very grateful to Prof. Dr. Mahmuda Naznin for her invaluable assistance and guidance. We would also like to sincerely thank our families, teachers and friends for their unwavering support and kindness.

Dhaka

May 2023

Taufiqun Nur Farid

Md. Shafaet Zaman

# Contents

<i>CANDIDATES' DECLARATION</i>	i
<i>ACKNOWLEDGEMENT</i>	ii
<i>List of Figures</i>	v
<i>ABSTRACT</i>	vii
<b>1 Introduction</b>	<b>1</b>
1.1 ASD Situation in Bangladesh . . . . .	2
1.2 PODD - Most Effective Tool . . . . .	5
1.3 Different types of PODD . . . . .	6
1.4 Why PODD is Widely Used? . . . . .	7
<b>2 Relevant Work</b>	<b>11</b>
2.1 Avaz - Picture and Text Communication [1] . . . . .	12
2.2 Language Therapy for Children - MITA . . . . .	14
2.3 Children's Speech Therapy at SPEECH BLUBS! . . . . .	17
2.4 Bolte Chai . . . . .	19
2.5 Ostimo . . . . .	21
2.6 Proloquo2Go . . . . .	25
2.7 General Technical Overview of The Apps . . . . .	28
<b>3 Problem Domain</b>	<b>30</b>
3.1 Emotion, Cognition and ASD . . . . .	30
3.2 Emotional Components . . . . .	32
3.3 Emotion Wheel Benefits . . . . .	32
3.4 Emotion Wheel Usage . . . . .	33
3.5 Proposed Design . . . . .	33
3.5.1 About PODD 9 words . . . . .	33
3.6 Development Steps of e-PODD . . . . .	39
3.6.1 Advantages of an Electronic Version . . . . .	40
3.6.2 Technical Challenges . . . . .	46

3.6.3	Limitations of PODD . . . . .	50
<b>4</b>	<b>Future Works</b>	<b>52</b>
<b>5</b>	<b>Results</b>	<b>54</b>
<b>6</b>	<b>Conclusion</b>	<b>59</b>
	<b>References</b>	<b>60</b>

# List of Figures

1.1	Autism Spectrum Disorder [Source: <a href="https://www.istockphoto.com/vector/autism-spectrum-disorder-infographic-presentation-template-with-icons-has-5-steps-gm1450472786-487379899">https://www.istockphoto.com/vector/autism-spectrum-disorder-infographic-presentation-template-with-icons-has-5-steps-gm1450472786-487379899</a> ] . . . . .	1
1.2	A Child with Special Needs [Source: <a href="https://thedailynewnation.com/news/91026/Children-with-Autistic-Spectrum-Disorder-(ASD)-in-Bangladesh">https://thedailynewnation.com/news/91026/Children-with-Autistic-Spectrum-Disorder-(ASD)-in-Bangladesh</a> ] . . . . .	2
1.3	4 Things to Remember [Source: <a href="https://cri.org.bd/2014/09/03/global-autism-movement-and-bangladesh/">https://cri.org.bd/2014/09/03/global-autism-movement-and-bangladesh/</a> ] . . . . .	3
1.4	Teaching Children with Special Needs [Source: <a href="https://www.alamy.com/stock-photo-dhaka-bangladesh-02nd-dec-2015-bangladeshi-many-autistic-children-90853407.html">https://www.alamy.com/stock-photo-dhaka-bangladesh-02nd-dec-2015-bangladeshi-many-autistic-children-90853407.html</a> ] . . . . .	4
1.5	PODD [Source: PODD Official Book] . . . . .	5
2.1	Avaz App [Source: <a href="https://www.avazapp.com/">https://www.avazapp.com/</a> ] . . . . .	12
2.2	Avaz App [Source: <a href="https://www.avazapp.com/">https://www.avazapp.com/</a> ] . . . . .	13
2.3	Avaz App [Source: <a href="https://www.avazapp.com/">https://www.avazapp.com/</a> ] . . . . .	14
2.4	MITA App [Source: <a href="http://surl.li/hiyv">http://surl.li/hiyv</a> ] . . . . .	15
2.5	MITA App [Source: <a href="http://surl.li/hiyv">http://surl.li/hiyv</a> ] . . . . .	16
2.6	MITA App [Source: <a href="http://surl.li/hiyv">http://surl.li/hiyv</a> ] . . . . .	17
2.7	Speech Blubs App [Source: <a href="https://speechblubs.com/">https://speechblubs.com/</a> ] . . . . .	18
2.8	Speech Blubs App [Source: <a href="https://speechblubs.com/">https://speechblubs.com/</a> ] . . . . .	19
2.9	Speech Blubs App [Source: <a href="https://speechblubs.com/">https://speechblubs.com/</a> ] . . . . .	20
2.10	Bolte Chai App [Source: <a href="http://surl.li/hiyzn">http://surl.li/hiyzn</a> ] . . . . .	21
2.11	Bolte Chai App [Source: <a href="http://surl.li/hiyzn">http://surl.li/hiyzn</a> ] . . . . .	22
2.12	Bolte Chai App [Source: <a href="http://surl.li/hiyzn">http://surl.li/hiyzn</a> ] . . . . .	23
2.13	Ostimo App [Source: <a href="https://otsimo.com/en/">https://otsimo.com/en/</a> ] . . . . .	24
2.14	Ostimo App [Source: <a href="https://otsimo.com/en/">https://otsimo.com/en/</a> ] . . . . .	25
2.15	Ostimo App [Source: <a href="https://otsimo.com/en/">https://otsimo.com/en/</a> ] . . . . .	26
2.16	Proloquo2Go App [Source: <a href="https://www.assistiveware.com/products/proloquo2go">https://www.assistiveware.com/products/proloquo2go</a> ] . . . . .	27
2.17	Comparison of the Apps . . . . .	29
3.1	Plutchik's Emotion Wheel [Source: <a href="https://www.mindbodygreen.com/articles/emotion-wheel">https://www.mindbodygreen.com/articles/emotion-wheel</a> ] . . . . .	31
3.2	A child using simPODD [Source: <a href="https://www.assistiveware.com/products/simpodd">https://www.assistiveware.com/products/simpodd</a> ] . . . . .	41

3.3	Data Collection Format . . . . .	42
3.4	Collected Data . . . . .	43
3.5	Data Permission . . . . .	44
3.6	App UI in an Android Smartphone . . . . .	44
3.7	Original PODD Book . . . . .	45
3.8	Bengali PODD App . . . . .	46
3.9	SingleTon Structure . . . . .	47
3.10	Usage of Inheritane to Avoid Redundancy . . . . .	49
5.1	Seminar on PODD . . . . .	55
5.2	Training on PODD . . . . .	56
5.3	Training on our e-PODD . . . . .	57
5.4	A Child Using Our e-PODD . . . . .	58

## **ABSTRACT**

The goal of this study is to improve communication for individuals with *nvASD*(*non-verbal autism spectrum disorder*) or *mvASD*(*minimally-verbal autism spectrum disorder*) using an Android App. The research aims to classify and clarify the intentions and messages of individuals with nvASD or mvASD, and to provide a new way of understanding their vocalization intent and facilitating communication between caregivers and non-verbal Autistic individuals who do not use traditional spoken communication words. We focus on the impact on the expressive communication development of AAC (Augmentative and Alternative Communication) users by parent modeling.

The Pragmatic Organisation Dynamic Display (PODD) is a communication system that uses pictures to help people with autism communicate their needs and wants. It is a very effective tool for people with autism who have difficulty communicating verbally.

In this thesis, we describe the development of an Android app for PODD both in English and Bengali. The app is designed to be a portable and user-friendly communication tool for people with autism. It includes a large library of pictures that can be used to communicate a wide range of needs and wants.

We tested the app with some children with autism. The results showed that the app was easy to use and helped the children communicate more effectively.

# Chapter 1

## Introduction

*Autism Spectrum Disorder* (ASD) is a group of neuro-developmental disorders that are characterized by repetitive behaviors, sensitivity to change and simulation, social interaction difficulties, motor difficulties, and communication challenges [2].

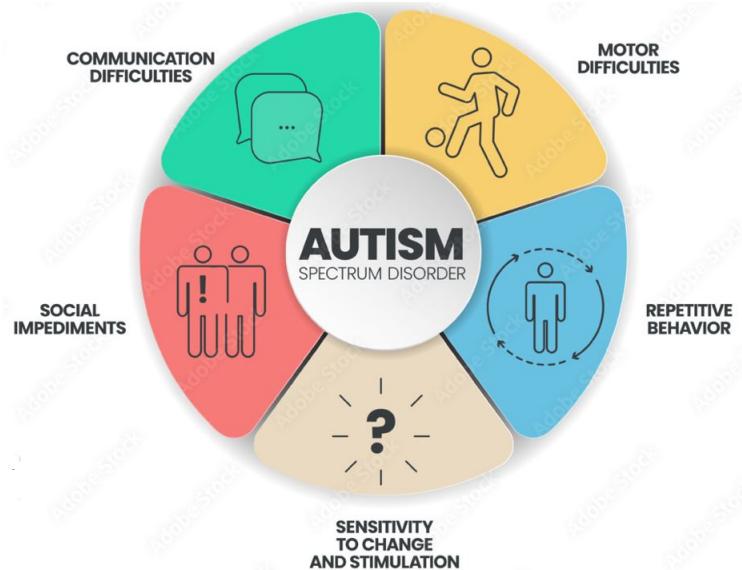


Figure 1.1: Autism Spectrum Disorder [Source: <https://www.istockphoto.com/vector/autism-spectrum-disorder-infographic-presentation-template-with-icons-has-5-steps-gm1450472786-487379899>]

It is a significant health burden worldwide, especially for a developing country like Bangladesh. An early diagnosis can improve the quality of life of people with special needs. This study focuses on technology's role in improving communication for individuals with non-verbal or minimally-verbal people with autism (nvASD or mvASD) [3]. This thesis aims to specify or detect the expression of their daily life and activities in non-verbal individuals and to develop technology that can enhance the vocalization or learning capability of people with nvASD and mvASD. The goal is to provide tools to help people better understand the expressions and needs

of those with nvASD or mvASD, facilitating communication between them and neurotypical people. The study also aims to provide novel ways to understand the expression of nvASD or mvASD individuals.



Figure 1.2: A Child with Special Needs [Source: [https://thedailynewnation.com/news/91026/Children-with-Autistic-Spectrum-Disorder-\(ASD\)-in-Bangladesh](https://thedailynewnation.com/news/91026/Children-with-Autistic-Spectrum-Disorder-(ASD)-in-Bangladesh)]

## 1.1 ASD Situation in Bangladesh

*Autism* is a prevalent neuro-developmental disorder that affects social interaction and communication, with an estimated 1% of the global population suffering from it [4]. In Bangladesh, it is estimated that one in every 600 children is diagnosed with an autism spectrum disorder, with many of them not progressing to functional verbal communication. About 25% to 50% of them do not progress to functional verbal communication [5]. Less than 20 words are used by minimally verbal people, and no spoken words are used by nonverbal people [6]. These individuals often use *Alternative and Augmentative Communication (AAC)* methods such as vocalizations, gestures, or contextual cues instead of spoken words to express their intentions and feelings. These vocalizations can provide complex information but can be difficult for listeners to understand. Furthermore, because these noises differ from person to person, it is very challenging to examine the subject in actual-world settings. A thorough investigation of this subject is thus

still lacking.

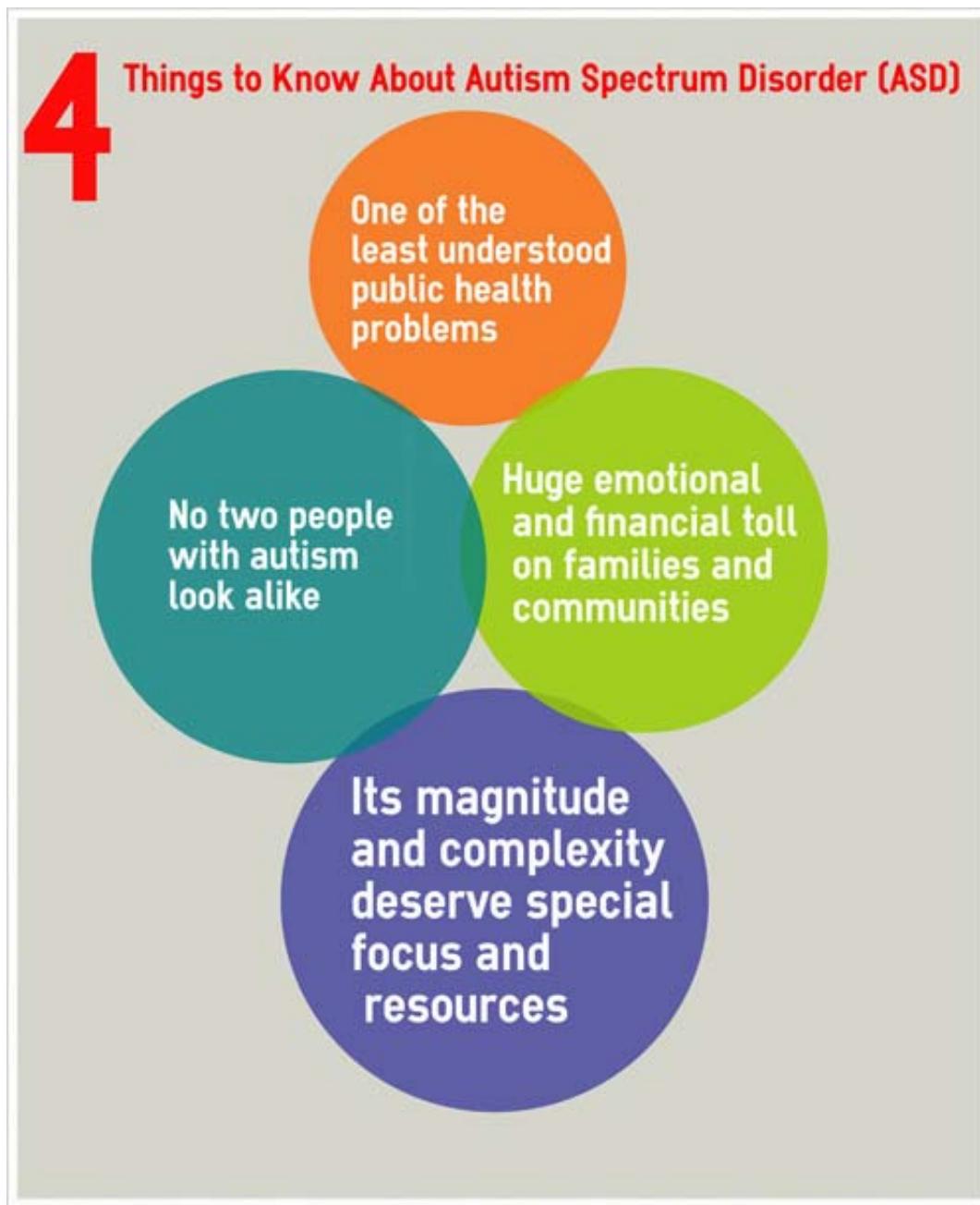


Figure 1.3: 4 Things to Remember [Source: <https://cri.org.bd/2014/09/03/global-autism-movement-and-bangladesh/>]

We do our research in collaboration with Dr. Tahmina Huq, Educational Therapist, Trainer, and Consultant, M Ed, Special Ed (Singapore), ACTA (Singapore), DDS (Australia), DCS (Australia), CIA (Singapore), MBBS (Bangladesh), a special education specialist for children with autism spectrum disorder (ASD) and an expert of PODD. She lives in Singapore and works as a consultant to train others in special education.

In this study, we focus on the development of communication among individuals who have complex communication needs (CCN) by involving their parents in the use of AAC (augmented



Figure 1.4: Teaching Children with Special Needs [Source: <https://www.alamy.com/stock-photo-dhaka-bangladesh-02nd-dec-2015-bangladeshi-many-autistic-children-90853407.html>]

tative and alternative communication). The core intent of using AAC is to provide individuals with CCN means to communicate and actively participate in life events (ASHA, 2004). Language is a vehicle of communication. Parents play a crucial role in their children's language development in order to communicate. It is an effortless process for typically developing children. As they are immersed in the language one is learning even before they are born (Langdon, 2008). They understand and use the learned words that are frequently spoken to them in a meaningful context. They develop their word stock when by using it meaningfully in different contexts(Gray, 2003; Pence Justice, 2008). On the contrary, there is a barrier to the development of language for children with CCN. They are expected to use their AAC to communicate when parents provide spoken language input (von Tetzchner & Grove, 2003; von Tetzcher Stadskleiv, 2016; Sennott, Light & McNaughton, 2016). To overcome this asymmetry of the modes of language stimulation for children with CCN, this study will emphasize parent-implemented interventions. Parents play a vital role in their children's daily AAC use, however, not many researchers explored this. We are aiming to investigate how parental involvement impacts the development of expressive language when parents use their child's AAC tool to communicate. We use the PODD (Pragmatic Organization Dynamic Display) communication system AAC tool. No previous experimental research has yet been done on parents introducing the PODD communication system in children's communication development. When planning for an intervention study, we have decided that a pilot intervention study would be most appropriate, as there was no previous research to identify the benefit of involving parents to model using the AAC tool as a communication partner. This study aims to investigate the impact on the development of the expressive language of children with complex communication needs when parents are used their AAC tool. as a first step, in preparation for a more rigorous study into this approach in the future.

## 1.2 PODD - Most Effective Tool

PODD stands for Pragmatic Organisation Dynamic Display, and it is a communication system designed for individuals who have complex communication needs. The system was developed by Gayle Porter [7], a speech pathologist, and has been used successfully with individuals of all ages, including children and adults with developmental disabilities, cerebral palsy, and other conditions that affect communication.

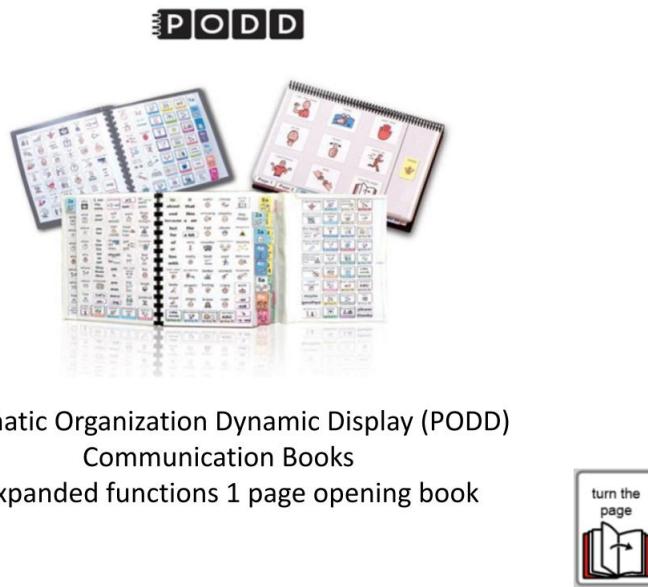


Figure 1.5: PODD [Source: PODD Official Book]

The PODD communication system is based on the idea of using a dynamic display of symbols to support communication. The symbols are organized into pragmatic communication functions, such as greetings, requests, comments, and questions, and are presented in a logical and predictable way to help users develop their communication skills.

PODD uses a range of symbols, including photographs, line drawings, and written words, to support communication. The system is designed to be flexible, allowing users to customize their communication displays to suit their individual needs and preferences.

One of the key features of the PODD system is its use of partner-assisted scanning. This involves a communication partner, such as a teacher or parent, pointing to symbols on the communication display in response to the user's gaze or other communication cues. This approach helps to promote social interaction and allows the user to communicate more effectively in a range of different settings.

PODD is often used as part of a comprehensive approach to communication support, which may include other assistive technologies, speech therapy, and social skills training. The system has been shown to be effective in improving communication skills and enhancing social interaction

for individuals with complex communication needs.

Overall, the PODD communication system provides a powerful tool for individuals with complex communication needs to communicate with others and engage more fully in their communities.

PODD is an effective learning tool and according to "Research in Developmental Disabilities", PODD was effective in helping children with autism communicate more effectively. Children who used PODD were able to communicate more often and more accurately than children who did not use PODD [8]. According to "Research in Autism Spectrum Disorders", PODD was more effective than other communication methods at increasing communication skills in children with autism [9]. According to, "Journal of Speech, Language, and Hearing Research", PODD was effective in helping adults with intellectual disabilities communicate more effectively. Adults who used PODD were able to communicate more independently and to participate more fully in their daily lives than adults who did not use PODD [10].

PODD has an electronic version called simPODD [11] which is only for the Apple ecosystem and that is a paid version. But in developing countries like Bangladesh apple devices are not that much popular and also people are not that eager to use an app that is paid.

That's why we have chosen PODD to turn it into an easily accessible Android App Version. Also, we have created a Bengali version of the app for the use of autistic non-verbal children in Bangladesh.

Key Features of PODD:

- Communication with icons
- Approved by American Speech-Language-Hearing Association (ASHA) [12]
- Used over 30 countries, like USA, UK, France, Canada, New Zealand, Australia etc.
- Flexible communication system
- Evidence-based communication system

## 1.3 Different types of PODD

PODD (Pragmatic Organisation Dynamic Display) is a communication system that can be adapted to suit the needs of different individuals with complex communication needs. Here are some of the different types of PODD systems available:

- **9 Words PODD:** This is the original PODD system developed by Gayle Porter, and it includes nine core communication functions, such as greetings, requests, comments,

questions, opinions, and emotions. It is for children or individuals who are starting their communication journey.

- **12 Words PODD:** This system includes the same nine core communication functions as the 9 Words PODD system, but also includes additional functions such as social interaction, problem-solving, and personal care. This system also provides more symbol options than the 9 Words PODD system, with up to 60 symbols per page. It provides a slightly expanded set of words to enhance communication possibilities.
- **15 Words PODD:** This system builds on the 12 Words PODD system by providing even more symbol options per page, with up to 84 symbols available. It offers further word options to support more expressive communication.
- **20 Words PODD:** This system provides up to 108 symbols per page, offering an even wider range of communication options for users. It provides a wider range of vocabulary and linguistic flexibility.
- **40 Words PODD:** This system is designed for more advanced communicators and includes up to 176 symbols per page, covering a wide range of communication functions and topics. It is suitable for individuals with complex communication needs and a higher level of language proficiency.
- **School PODD:** This system is designed specifically for use in educational settings, with symbols organized by school-related functions such as classroom activities, social interactions, and playground activities. It supports academic and social communication in school environments.
- **Adult PODD:** This system is designed for adults with complex communication needs, and includes symbols for a wide range of topics such as employment, relationships, and personal care. It is tailored for adults with complex communication needs.

The choice of which PODD system to use will depend on the individual's communication needs, abilities, and preferences, as well as the recommendations of their speech-language pathologist or other communication specialist. We have implemented the 9 word PODD for the basics version.

## 1.4 Why PODD is Widely Used?

PODD (Picture Exchange Communication System) is a communication system that uses pictures to help people with autism communicate their needs and wants. It is a very effective tool

for people with autism who have difficulty communicating verbally. PODD is better than other learning tools for autism because it is:

- **Visual:** People with autism often learn best visually, and PODD uses pictures to make communication easier.
- **Functional:** PODD is designed to be used in everyday situations, so it helps people with autism communicate in the real world.
- **Flexible:** PODD can be customized to meet the individual needs of each person with autism.
- **Ecological:** PODD can be used in a variety of settings, including home, school, and the community.

PODD has been shown to be an effective communication tool for people with autism. In a study published in the journal "Research in Autism Spectrum Disorders" researchers found that PODD was more effective than other communication methods at increasing communication skills in children with autism.

If you are looking for a communication tool for your child with autism, PODD is a great option. It is a visual, functional, flexible, and ecological tool that can help your child communicate more effectively.

Here are some additional benefits of using PODD:

- PODD can help people with autism develop their language skills.
- PODD can help people with autism learn to express their emotions.
- PODD can help people with autism make choices and decisions.
- PODD can help people with autism interact with others.
- PODD can help people with autism participate in activities.

If you are interested in learning more about PODD, you can visit the PODD website or talk to your child's doctor or therapist.

PODD is used in over 30 countries around the world [?].

The countries that use PODD include:

Australia, Austria, Belgium, Brazil, Canada, China, Denmark, Finland, France, Germany, Greece, Hong Kong, Ireland, Italy, Japan, Korea, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Russia, Singapore, Spain, Sweden, Switzerland, United Kingdom, United States.

PODD is a valuable tool for people with autism and their families. It can help people with autism to communicate their needs and wants, and to participate more fully in their lives.

PODD, or Picture Exchange Communication System, is a communication system that uses pictures to help people communicate. It is a visual communication system that is designed to be easy to use and understand. PODD is used by people with a variety of communication needs, including those with autism, intellectual disabilities, and other developmental delays.

PODD is a comprehensive communication system that can be used for a variety of purposes, including:

- Expressing wants and needs
- Communicating about past, present, and future events
- Asking questions
- Following directions
- Expressing feelings
- Socializing
- Problem-solving

PODD is a flexible communication system that can be adapted to meet the individual needs of each user. The system includes a variety of features that make it easy to use, including:

- Large, high-contrast pictures
- Simple, easy-to-read text
- A variety of communication boards and books
- A variety of accessories, such as communication wallets and lanyards

PODD is an evidence-based communication system that has been shown to be effective in helping people communicate. The system is approved by the American Speech-Language-Hearing Association (ASHA) and is used by people in over 30 countries around the world.

Here are some of the specific features of PODD that make it an effective communication system:

**Pictures:** PODD uses high-quality, large, and high-contrast pictures that are easy to see and understand. The pictures are also simple and easy to read, which makes them accessible to people with a variety of communication needs.

Text: PODD includes simple, easy-to-read text that is paired with pictures. This text helps to provide additional information about the pictures and can be helpful for people who are learning to read or who have difficulty reading.

Various communication boards and books: PODD includes a variety of communication boards and books that can be customized to meet the individual needs of each user. The boards and books come in a variety of sizes and formats, and they can be used for a variety of purposes, such as expressing wants and needs, communicating about past, present, and future events, asking questions, following directions, expressing feelings, socializing, and problem-solving.

Various accessories: PODD includes a variety of accessories that can be used to make the system more portable and convenient. These accessories include communication wallets and lanyards, which can be used to carry the communication boards and books with you.

PODD is a comprehensive and effective communication system that can be used by people with a variety of communication needs. The system is easy to use and understand, and it is backed by evidence. If you are looking for a communication system that can help you or someone you know communicate more effectively, PODD is a great option.

Autism is a developmental disorder that affects communication and behavior. People with autism often have difficulty communicating verbally. This can make it difficult for them to express their needs and wants, and to interact with others.

The PODD is a communication system that uses pictures to help people with autism communicate. PODD is a very effective tool for people with autism who have difficulty communicating verbally.

The PODD system consists of a set of pictures that represent different words and phrases. People with autism can use the pictures to communicate their needs and wants by exchanging them with a communication partner.

PODD is a very flexible system. The pictures can be arranged in different ways to create different messages. This makes PODD a very versatile tool that can be used in a variety of settings.

There is a growing body of research that supports the use of PODD for people with autism. In a study published in the journal "Research in Autism Spectrum Disorders," researchers found that PODD was more effective than other communication methods at increasing communication skills in children with autism.

Another study, published in the journal "Autism," found that PODD was effective in improving the social interactions of children with autism.

# **Chapter 2**

## **Relevant Work**

In this chapter, we talk about the related research work. Here, we describe some widely used learning tools for the children or young adults with ASD. We also discuss different features and benefits of those learning apps and tools for autistic individuals.

1. Visual aids (e.g. pictures, videos) to help with comprehension
2. Repetition and reinforcement of concepts
3. Customized settings to adjust the level of difficulty
4. Social skills training
5. Speech and language therapy
6. Monitoring and progress tracking for parents and caregivers

It's important to note that different apps may have different focuses and target different skills. It would be best to research and compare specific apps to determine which one best fits one's needs.

Avaz, Avaz Bangla, MITA, Otsimo and SPEECH BLUBS are apps that provide speech therapy and use visual aids to help with comprehension. Avaz and Avaz Bangla are similar with the only difference being the language it supports. MITA is also similar but it supports English, Spanish, Portuguese, Russian, German, French, Italian, Arabic, Farsi, Korean, and Chinese Languages. SPEECH BLUBS is focused on children aged 0-6 years and support multiple languages. Bolte Chai is similar to the other apps but it also includes training on social skills.

## 2.1 Avaz - Picture and Text Communication [1]

Avaz AAC (Augmentative and Alternative Communication) is an award-winning communication and learning software for people with autism, cerebral palsy, Downs Syndrome, aphasia, and apraxia, as well as any other speech impairment. Avaz has 75,000 users in 180 countries since 2011. Avaz aids speech-impaired people. It helps users overcome language barriers and express their feelings, needs, and wishes by including global speech therapists, special educators, and language specialists. Avaz's research-based vocabulary of over 15,000 photos offers the greatest chance for speech development. Starting with a basic touch of words and learning to compose phrases, users may develop individuality and express themselves wherever. Avaz offers high-quality voices and regionally appropriate languages for user convenience. Avaz now has four country-specific vocabularies in the Play Store: US, Australia, India, Sri Lanka, France, Hungary, Sweden, UK. Android devices may use Avaz. Avaz's Android version is user-friendly and customizable. Share emails, WhatsApp, and other popular social media messages with friends and family easily! Avaz also allows print and utilize own book.



Figure 2.1: Avaz App [Source: <https://www.avazapp.com/>]

Highlighting excellent aspects:

1. An easy-to-use home screen.
2. Readable, visually appealing themes
3. Good voices like ReadSpeaker
4. Customised word morphologies
5. Navigability, editing, and more!

Avaz wants every voice heard. Avaz AAC enables optimal communication. Communication and

a large vocabulary help people learn. Avaz builds confidence and enjoys their AAC journey with greater communication and learning. Avaz AAC offers a 14-day trial sans credit card! To keep using all the great services, they offer reasonable monthly, annual, and lifetime subscriptions. Avaz adapts to user changes via app upgrades and support tools. It empowers users, parents, carers, and experts by celebrating every milestone. Avaz helps educators teach and study most academic disciplines worldwide.

Minimal specs:

Android version: Minimum 6.0; Recommended 7.0+

Screen size—5”;

RAM—Min 1GB; Recommended 2GB

Storage—Min 1.5GB



Figure 2.2: Avaz App [Source: <https://www.avazapp.com/>]

Main features of Avaz:

- AAC (Augmentative and Alternative Communication)
- 75,000 users in over 180 countries
- Vocabulary of over 15,000 pictures
- Four country-specific vocabularies
- Use Modified Fitzgerald Color Coded Key

The App has many facilities, but not without any limitations. Limitations of the Avaz App:

1. The Bengali version is not as enriched as the English version.
2. This app is totally paid.
3. No free version is available.



Figure 2.3: Avaz App [Source: <https://www.avazapp.com/>]

## 2.2 Language Therapy for Children - MITA

Early intervention language treatment for kids with autism and language delay is provided by MITA.

It is the first and only language therapeutics application backed by clinical data.

Young children who trained with MITA increased their language score at the end of the study on average 2.2 times more than comparable children who did not utilise MITA, according to a 3-year clinical trial involving 6,454 autistic children. [13] Statistics showed that this difference was significant.

- Consists of limitless cognitive and language activities made to last ten years.
- Over 1,000,000 children with language delays use it; it was named the best autism app by Healthline; and it is available in a number of different languages, including English, Spanish, Portuguese, Russian, German, French, Italian, Arabic, Farsi, Korean, and Chinese.
- For kids with autism and language delay, Mental Imagery Therapy for Autism (MITA) is a novel early-intervention programme. MITA teaches language and mental integration,



Figure 2.4: MITA App [Source: <http://surl.li/hiyyv>]

beginning with basic vocabulary and working up to more complex language elements like adjectives, verbs, pronouns, and grammar.

- MITA EDUCATIONAL ACTIVITIES Based on language therapy approach of following directions with increasing complexity. Based on ABA techniques of visual-visual and auditory-visual conditional discrimination.
- Based on Pivotal Response Therapy, which aims to develop responses to many inputs.
- Identify colors, patterns, and sizes. Each activity is adaptive and delivers exercises at the precise level of difficulty appropriate for your child at any particular point in time.
- Include things in a cohesive image.
- Use spatial prepositions as on, under, behind, and in front; Prepositions of time: Before/After; Passive verb tenses; Subject/Object; Reading and Writing; Numbers and counting; Arithmetic; Logic and reasoning; Mental perspective-taking; Mental mathematics.
- Playtime rewards to keep your child interested while learning and having fun.
- No Wi-Fi required; No advertisements.

MITA enhances a child's verbal and creative abilities. The visual activities provide a methodical process to help children learn to recognise a variety of aspects in an object. MITA begins with easy exercises that educate kids to focus on a single element, like size or colour. As the exercises progress, they get more challenging and call for the youngster to focus on two features at once,

such size and colour. After a youngster has gotten some practice paying attention to two aspects, the programme progresses to puzzles that call for paying attention to three qualities, including colour, size, and form, and subsequently to puzzles that call for paying attention to an ever-increasing number of characteristics. The verbal exercises provide a more traditional method of learning a language, starting with basic vocabulary and moving up to more complex language elements like adjectives, prepositions, and syntax.



Figure 2.5: MITA App [Source: <http://surl.li/hiyyv>]

MITA is created for young children and is meant for everyday, long-term use. It is entertaining and informative, adaptable, and sensitive to the unique skills of each child. MITA exercises can be used as an adjunct to traditional speech therapy for kids with language delay, ASD (autism spectrum disorders), PDD (pervasive developmental disorders), intellectual and developmental disability (IDD), Down syndrome, and other neurodevelopmental problems.

A. Vyshedskiy, a neuroscientist from Boston University, R. Dunn, a specialist in early childhood development with a Harvard education, J. Elgart, a graduate of MIT, and a team of award-winning designers and artists who have worked with seasoned therapists have created MITA.

So, the main features of MITA are:

- Mental Imagery Therapy for Autism (MITA)
- Used by over 1,000,000 children
- Based on ABA techniques of visual-visual and auditory-visual conditional discrimination
- 3-year clinical trial of 6,454 children, improved 2.2-times more than similar children who did not use MITA

However, this app is not free of cost. Moreover, this application requires large memory.

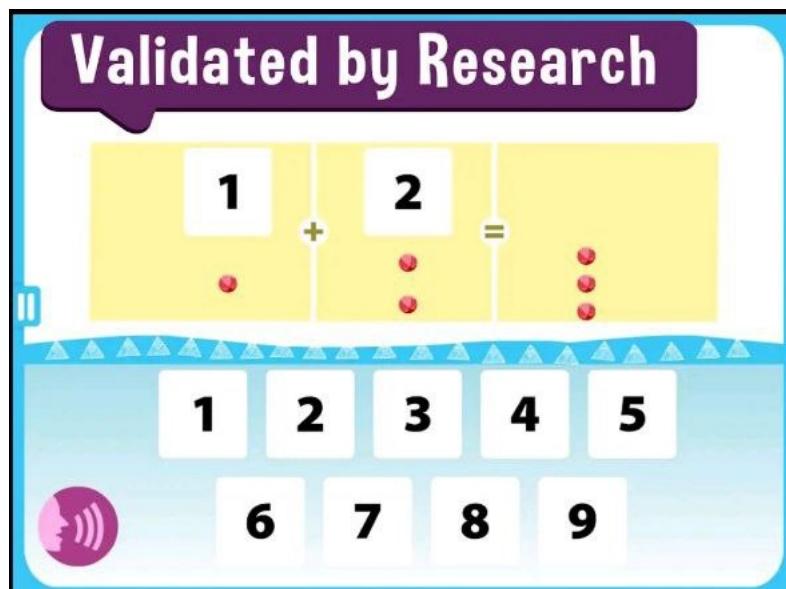


Figure 2.6: MITA App [Source: <http://surl.li/hiyyv>

## 2.3 Children's Speech Therapy at SPEECH BLUBS!

Speech Blubs has been highlighted in Thrive Magazine, Autism Parenting, Brisbane Kids, Speech Chick Therapy, Beautiful Speech Life, and The Speech Teacher, among other publications. Speech Blubs, which is aided by Facebook's Start Program, was further recognized by taking home the Social Impact award. [14] With the aid of this voice-activated speech therapy software, children may practice speaking in a motivating setting while learning new words and sounds. Our 1500+ exercises have been utilized more than 1,000,000 times to encourage the production of sounds and words in toddlers, late talkers (speech delay), children with apraxia of speech, autism, Down syndrome, ADHD, and sensory processing disorder, for which we are pleased, if not a little taken aback.

- Speech Blubs has over 1500 exercises, activities, hilarious headgear, films, mini-games, and other things to help you improve your speech effectively.
- Weekly releases of fresh, intriguing stuff!
- Uses 25 entertaining activity themes, including Early Sounds, When I Grow Up, Get into Shapes, Living Colors, This Is My Body, Mouth Gym, Animal Kingdom, Ride Your Wheels, Sing Along, Guess the Word, Guess the Sound, NUMB3R5, and many more.
- Has voice-activated functionality for a fun, interactive learning experience
- Uses facial detection to create amusing special effects like funny hats and masks in real time
- Lets you collect stickers and fill your sticker book as your child advances



Figure 2.7: Speech Blubs App [Source: <https://speechblubs.com/>]

- Offers humorous and educational content meant to spark conversation
- Techniques for learning have been researched.

UCLA researchers have shown that real-time peer observation activates MIRROR NEURONS, which have been found to be very helpful in the development of speech, in a study published by the American Speech-Language-Hearing Association (ASHA). Children may see their classmates being taught in real-time on video thanks to Speech Blubs' use of video modeling to create an immersive learning environment.

New content is regularly released in this app. Finally, an app that offers an almost limitless amount of entertaining stuff for your children to enjoy, including over 1500 activities, workouts, amusing hats and masks, effects, films, mini-games, and more! Every week, our staff puts out a lot of effort to provide engaging new material.

The terms, pricing and subscription of the app:

Start with a 7-day free trial to check out the app, get access to unlocked content, and get started. Your monthly or yearly membership price will be deducted from your GooglePlay account in order to subscribe (and maintain access to all the practices). a recurring transaction that will continue until you cancel your account at least 24 hours before the current subscription month expires. By logging into your GooglePlay account, you may alter your membership, change the



Figure 2.8: Speech Blubs App [Source: <https://speechblubs.com/>]

frequency of renewals, or cancel at any time. When you subscribe, you will lose any unused time from a free trial period.

So, the features of Speech Blubs are:

- Voice-controlled speech therapy app
- Won The Social Impact Award and is supported by Facebook's Start Program
- 1500+ exercises, activities
- 25 fun activity themes

This app is not without any limitations. It is totally paid and requires huge memory. Installation time is very high for this app.

## 2.4 Bolte Chai

An app to assist kids communicate their needs, whether they are speaking, nonverbal, or autistic. They may practice doing their work or tasks on their own by using this program. They can also converse with others using this app. 'Bolte' Chai' is used to launch the application.

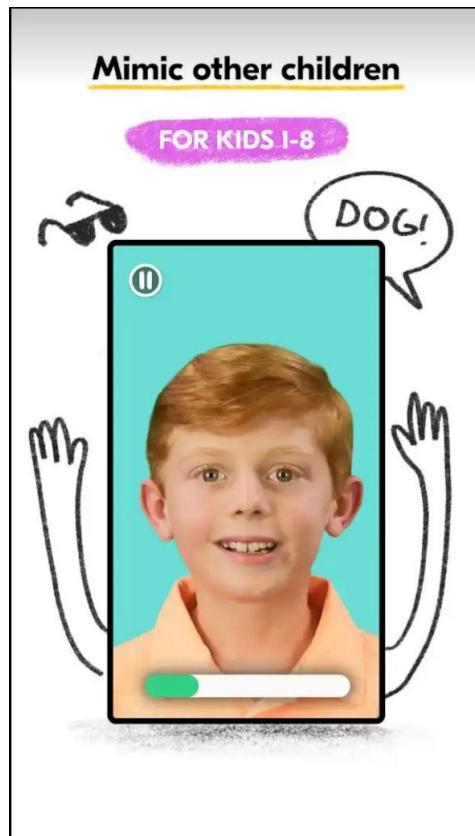


Figure 2.9: Speech Blubs App [Source: <https://speechblubs.com/>]

- A list of many categories, such as "Home, Out, Hungry," etc., as well as ",,," in Bangla, will be shown.
- Tap the right upper corner to change the language to English or Bangla, the mood for the youngster, or the mood for the parent. Create help contacts as you see fit for the protection of your children.
- A new page of subcategories will emerge when you tap on any of the categories.
- For instance, if you touch the category for emotions, the subcategories Happy, Sad, Hungry, etc. will appear. Click or tap on the item you wish to convey.
- The categories may be changed as desired by doing the next several steps.
- First, press the "+" symbol in the bottom right corner. Next, a new tab will appear. Fill in the category name, add any relevant images or music, and then hit "Save."
- Long press any category or subcategory to see further choices, including Edit & Delete.

So, the features of the App are:

- A Bangladeshi Research Based App



Figure 2.10: Bolte Chai App [Source: <http://surl.li/hiyzn>]

- An App for verbal, non-verbal or autistic children
- A list of some categories will be shown like “Home, Out, Hungry” etc.
- Categories are customizable

There are many limitations of the app. It is a very Simple App with little features and has no specific medical background.

## 2.5 Ostimo

An innovative and entertaining pocket With the use of video modeling, SLP (Speech and Language Pathology) serves as a speech-language therapist!

Speech Therapy Pronunciation — Otsimo The only speech therapy software that makes use of voice and speech recognition technology, machine learning, and understanding precisely what you are attempting to say is Articulation.



Figure 2.11: Bolte Chai App [Source: <http://surl.li/hiyzn>]

For those who have speech-related problems like:

- Delayed speaking (late talkers),
- Down syndrome that affects speech and nonverbal autism,
- Difficulty enunciating and articulating oneself,
- Stuttering, apraxia of speech, and aphasia
- Articulation problems

may practice their speech with Otsimo — Speech Therapy

Pronunciation Articulation in an attempt to improve it. Under the direction of parents, speech-language pathologists (SLPs), and specialists in therapeutic activities, speech games tailored to particular people are developed.

The goal of the assistive games in Otsimo — Speech Therapy

Pronunciation Articulation is to enhance communication and speaking abilities.



Figure 2.12: Bolte Chai App [Source: <http://surl.li/hiyzn>]

#### Reasons for using Otsimo — Speech Therapy:

- They improve the experience of speech therapy by using voice and speech recognition technologies to accurately assess what is being spoken.

The program measures if the articulation and pronunciation are becoming better using responsive machine learning technology. Each speech drill is followed by amusing filters, which are rewarded with hats and masks to make learning more entertaining.

- Additionally, there are 200+ stickers for each speech exercise, which motivates the patient to participate more actively in the speech treatment.

The repetition-based exercises, a common technique in ABA speech therapy, aid in the development of the individual with speech difficulties. They employ video modelling, which permits learning from peers via imitation, as part of licensed professional treatment. So that you never grow tired of learning new words, their applications are updated weekly with engaging material and speech exercises.

Otsimo — Speech Therapy Pronunciation Articulation will instruct students on the proper articulation of vowels, consonants, and other sounds for learning and development objectives. This



Figure 2.13: Ostimo App [Source: <https://otsimo.com/en/>]

will help students enhance their oral communication skills.

A portable SLP called Ostimo — Speech treatment Pronunciation Articulation may be used for at-home speech treatment. It promises to lessen any language and speech issues in a pleasant approach after winning an award for the best treatment activities app!

First Words, Basic Shapes, Body Parts, Safari Club, Tongue Acrobatics, and Rainbow Splash are just a few of the 15+ categories in the Ostimo — Speech Therapy app. Every group has been created to encourage the child's ability to produce sound.

The adventure with Ostimo — Speech Therapy SLP begins with a seven-day free trial or monthly membership. They provide subscriptions that are monthly, yearly, and lifetime. A lifetime membership costs \$119.99, a monthly subscription costs \$6.99, and an annual subscription costs \$4.49. Depending on your place of residency, the actual costs could be translated to the local currency. Payment will be deducted from your Google Play account at the time of confirmation of the transaction.

Speech Therapy Pronunciation — Ostimo A guardian may employ articulation that has been produced in this manner. The service has no restrictions on who may use it or their age.

So, the main features are:



Figure 2.14: Ostimo App [Source: <https://otsimo.com/en/>]

- SLP (Speech and Language Pathology)
- Speech games designed under the guidance of parents, speech-language pathologists (SLPs), and therapeutic activity experts
- ABA speech therapy
- 15+ categories, including First Words, Basic Shapes, Body Parts, Safari Club, Tongue Acrobatics, Rainbow Splash!

The limitation of the app is it is totally paid and very bulk in size. It is not supported in all Android versions.

## 2.6 Proloquo2Go

With the use of the software Proloquo2Go, educators and speech therapists may provide children with speech impairments or no speech at all another means of communication. It presents text and pictures on "buttons" in a flexible, multi-size grid structure. Buttons stand in for a variety of goods, movements, "little words," and other things. Students have the option of using



Figure 2.15: Ostimo App [Source: <https://otsimo.com/en/>]

single words or word combinations to construct complex phrases that communicate their desires, needs, or emotions—basically anything. You may create buttons using images that are personal to each user or your own graphics. Students may create complex and meaningful words as they type or press keys using a typepad that can be adjusted for fine-motor skill delays or repeated motions ("I'm weary. Please take a break for me. If requested, the app may speak students' messages in a variety of voices, including those that are young (British or American, boy or female, and more). Words may be grouped both by type (such as verb, noun, or pronoun), as well as by a wide range of categories (such as food, family, or occupations). Additionally, there is support for multilingual usage. It involves some preparation and familiarity with the requirements and preferences of each student. The user experience will then be continually improved by continuing modification; changing settings and using each feature is quite simple. For instructors and therapists who deal with numerous children, once the fundamentals are learned, selecting or adding additional terms and structuring options in more efficient ways will probably come naturally. Students may improve their communication skills and emotional recognition with the aid of Proloquo2Go. This might assist many speech-limited adolescents improve their academic abilities, lessen classroom frustration, and enhance social interactions with adults. The creators are attempting to be inclusive with new improvements, including gender-neutral pronouns, more diverse voice casting, and female superhero icons.

The main features of the App are:

- Text and pictures on "buttons"
- Improve their communication skills and emotional recognition
- Augmentative and Alternative Communication (AAC) app
- Help to Grow and develop
- Communicate with ease

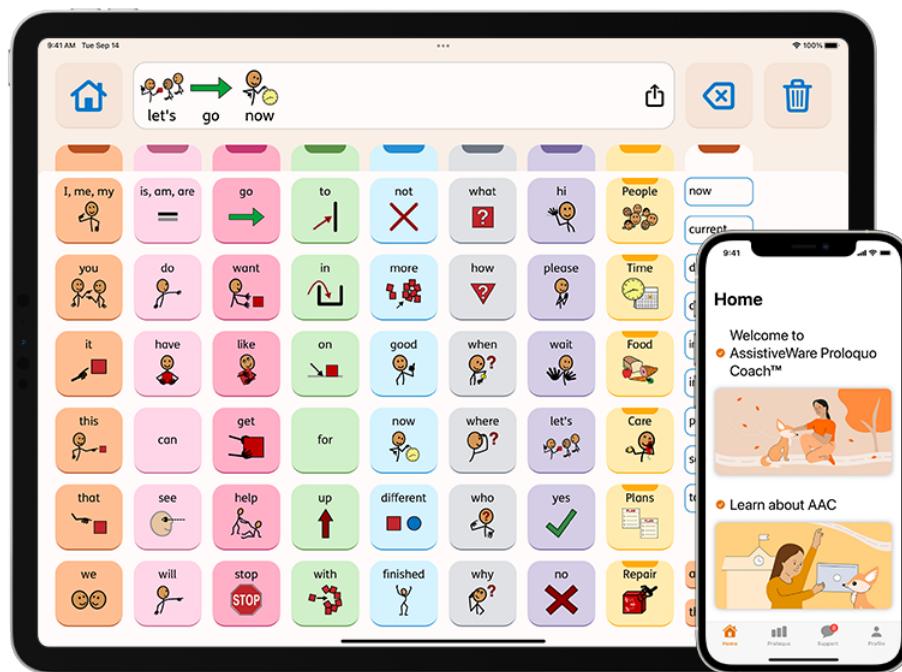


Figure 2.16: Proloquo2Go App [Source: <https://www.assistiveware.com/products/proloquo2go>]

The limitations of the app are: It is totally paid, very costly, and very bulk in size. It is only available on iOS devices, no Android version is available.

So, here is a comparison chart of all the apps available till now.

App Name	Target Age	Language	Speech Therapy	Visual Aids	Social Skills
Avaz	3-12 years	English	Yes	Yes	No
MITA	3-12 years	Multiple	Yes	Yes	No
Avaz Bangla	3-12 years	Bengali	Yes	Yes	No
SPEECH BLUBS	0-6 years	Multiple	Yes	Yes	No
Bolte Chai	3-12 years	Bengali	Yes	Yes	Yes

## 2.7 General Technical Overview of The Apps

Minimal specs: Android version: Minimum 6.0; Recommended 7.0+ Screen size—5”; RAM—Min 1GB; Recommended 2GB Storage—Min 1.5GB Avaz:

- An offline app, that doesn't require a constant internet connection
- Utilizes local device storage to store user data
- Does not rely on cloud storage
- Available for both iOS and Android devices

Proloquo2Go:

- Designed to work offline and doesn't require a continuous internet connection
- Uses local device storage for storing user data and communication files
- Available only for iOS devices

Speech Blubs:

- Utilizes a combination of offline and online functionality
- The initial download and core features of the app work offline
- Additional content, updates, and user progress synchronization may require an internet connection
- Use cloud storage to save user data and synchronize it across multiple devices
- Available for iOS and Android devices

### Reviews of Some Prominent Learning Apps Designed for Individuals with Autism

Apps	Target Age	Language	Aim	Speech Therapy	Visual Aids	Social Skills	Technology Used	Users	Vocabulary	Year	Policy
Avaz	3-12 years	English, four country-specific vocabularies – for US, Australia, India, Sri Lanka, France, Hungary, Sweden, UK	Communicate and express using pictures & text	Yes	Yes	No	Mental Imagery Therapy for Autism (MITA) Based on ABA techniques of visual-visual and auditory-visual conditional discrimination	Used by over 1,000,000 children with language delay	(Fitzgerald) color coded vocabulary of over 15,000 pictures	2011	monthly, yearly and lifetime subscription plans
MITA	3-12 years	English, Spanish, Portuguese, Russian, German, French, Italian, Arabic, Farsi, Korean, and Chinese Languages	Early intervention language therapy for children with language delay and autism	Yes	Yes	No	(Augmentative and Alternative Communication)	75,000 users in over 180 countries	(Fitzgerald) color coded vocabulary of over 15,000 pictures	2011	monthly, yearly and lifetime subscription plans
Avaz Bangla	3-12 years	Bengali	Communicate and express using pictures & text	Yes	Yes	No	voice-controlled speech therapy app	1500+ exercises, activities, funny hats, videos, mini-games, and more		monthly or annual subscription fee	
SPEECH BLUBS	0-6 years	Multiple	Speech Therapy For Kids	Yes	Yes	No				free	
Bolte Chai	3-12 years	Bengali	for verbal, non-verbal or autism child, to help them express their needs	Yes	Yes	Yes	SLP (Speech and Language Pathology)	aba speech therapy		monthly, annual and lifetime subscriptions	
Otsimo				Yes	Yes	No					

Figure 2.17: Comparison of the Apps

# Chapter 3

## Problem Domain

### 3.1 Emotion, Cognition and ASD

The emotion wheel is a psychological technique that helps individuals understand and describe their complex feelings. The wheel identifies eight basic human emotions and tiers of related, more complex variants. Primary emotions are fundamental feelings that humans are born with and that have been hardwired into our brains.

The feelings wheel has many forms, but its major goals are to illuminate our inner world, pinpoint the intricacies of our emotional condition, and understand their depth and importance. Robert Plutchik's flower-shaped emotion wheel reveals our emotions' complex relationships. He believed that eight primal emotions underlie all other emotions in all their ranges and intensities, despite the fact that humans might experience more than 34,000 emotions.

Secondary emotions are emotional reactions to core emotions. Sorrow, anger, contempt, joy, trust, fear, surprise, and anticipation as the "eight basic feelings in the emotion wheel." Anger causes humiliation and dread.

The fundamental emotions are placed on the emotion wheel's axis in comparable groupings and opposite their real counterparts to generate their polar opposites.

#### Primary Emotions :

1. **Sorrow:** Gloominess, dissatisfaction, sorrow, apathy, despair, loneliness, and lethargy.
2. **Anger:** A subjectively unpleasant emotional state caused by real or perceived injury to a person or their ideals. Anger, wrath, and unhappiness may cause fighting.
3. **Disgust:** Aversion, repulsion, and rejection or desire for touch are disgusting. Disgust helps reproduction and avoids dangerous drugs and environments.

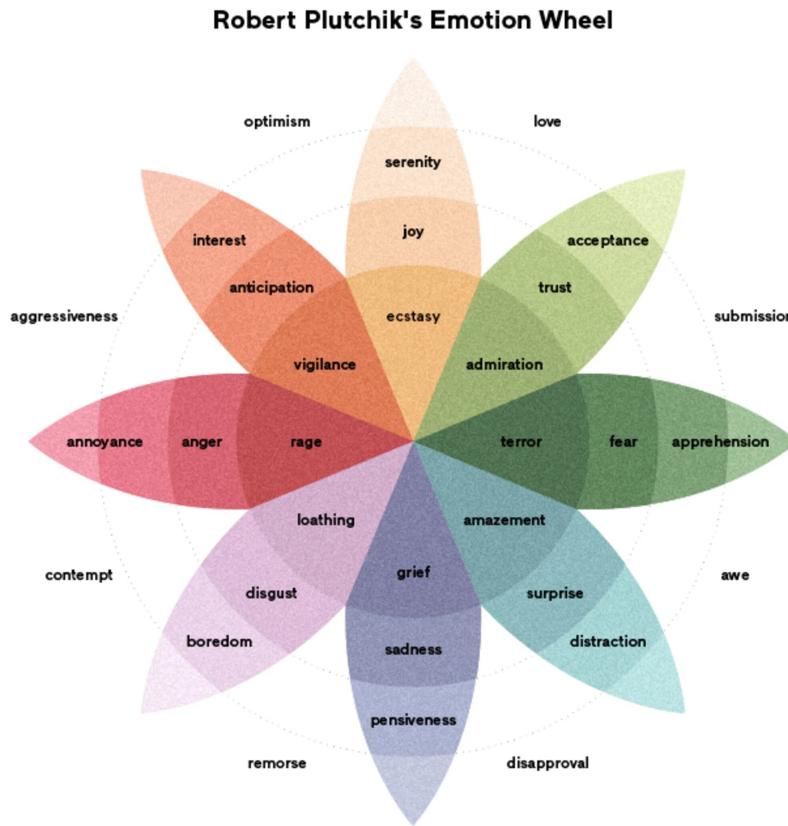


Figure 3.1: Plutchik's Emotion Wheel [Source: <https://www.mindbodygreen.com/articles/emotion-wheel>]

4. **Joy:** Extreme satisfaction, joy, ecstasy, victory, and celebration. It maintains successful actions.
5. **Trust:** Hope, safety, and faith in others. It shapes their worldview and begins psychological development.
6. **Fear:** An inherent sense that might manifest as frankness, apprehension, unease, concern, anxiety, uncertainty, or panic. It helps biologically prevent associative learning dangers.
7. **Astonishment:** A discrepancy between expectations and reality may elicit amusement, astonishment, awe, disbelief, and speechlessness.
8. **Anticipation:** It includes excitement, enthusiasm, impatience, pleasure, expectations, unpredictability, and waiting. Anticipation involves current awareness and future preparation.

Like colors, moods may be mixed to depict different feelings.

## 3.2 Emotional Components

Emotions are not isolated events. The body reacts to the mind. Research shows that dynamic variables in our emotions influence our actions. Analyzing emotions helps us understand and appreciate their importance. Their uses:

1. **Emotional Aspect:** Emotion is an inherent feeling aimed at a person, location, or experience. It's merely understanding that something is occurring that you may need to react to depending on contextual clues and external inputs.
2. **Action Tendency:** Each feeling is accompanied by a want to act or express oneself, known as an action tendency.
3. **Evaluating Factor:** As our body integrates our emotional response, we evaluate the surroundings for context, clues, behaviors, stimuli, or people that may be causing the experience.
4. **Motor Component:** The thalamus analyzes our muscular information for further processing. Our facial expressions, such as sobbing, laughing, or frowning, help us communicate our emotions.
5. **Biology:** Motor and physiological responses to emotion might make it easy for spectators to tell how we are feeling, based on involuntary body reactions like sweaty hands. These physiological reactions could include shallow breathing, a racing heartbeat, increased blood flow, or irregular digestion.

## 3.3 Emotion Wheel Benefits

The emotion wheel helps people visualize different emotional spectrums, which promotes self-expression and self-compassion. Empathize to strengthen relationships. The emotion wheel helps people communicate successfully. Being able to recognize and express their feelings in a healthy manner may also help reduce the intensity of their emotions, such as rage, stress, and sadness. The emotion wheel helps people understand, control, and communicate their emotions, which promotes emotional maturity and reduces emotional impulsivity and destructiveness. Most importantly, knowing you're OK and that what you're going through is normal makes you feel less powerless. Emotional needs are sensations or situations that make us feel comfortable, pleased, or at peace. Without them, we may feel wounded or frustrated. Emotional needs include respect, prosperity, safety, and community. Like physical sustenance, humans need emotional nourishment.

## 3.4 Emotion Wheel Usage

The wheel may help one confront one's true feelings, make the best choice, and reach a satisfying ending. Wheel usage is versatile. Listening to one's body and focusing on internal and external factors that may be influencing one's feelings can help one slow down and co-regulate. By assisting users in visualizing their emotions and understanding which combinations of emotions led to particular outcomes or behaviors, the emotion wheel helps people connect with their feelings. Additionally, seeing the opposing emotion might help people develop their emotional intelligence.

We can use the emotion wheel when confused about feelings. Starting there may seem easy, but avoiding emotions may make it hard. Though difficult, dealing with emotions in the moment often makes them worse. Emotions empowers one to go ahead. According to the expert, "frequent misunderstanding or miscommunication between partners," "difficulties understanding the emotions and behaviors of their friends or family," and "wanting to become more assertive and expressive of their emotions and needs" may benefit from it. As you become more aware of your needs and comfortable with your emotions, it will become less overwhelming.

In 1980, psychologist Robert Plutchik devised the wheel of emotions to describe the link between the most basic human emotions. Anger, excitement, joy, trust, fear, surprise, sorrow, and disgust are the eight basic human emotions, according to Plutchik. Plutchik's wheel of emotions includes the eight basic emotions, which are favorably and negatively connected when adjacent to each other. Interval angle on the emotion wheel indicates psychological link between emotions. He and Jin used graph convolutional neural networks to identify visual emotions in 2019. [15]

This work's model structure is simple, and the prior-aware graph convolutional network is trained independently. No EDL project has directly integrated psychological information from the emotion wheel into the deep learning network via the attention method.

## 3.5 Proposed Design

### 3.5.1 About PODD 9 words

Developed over the past 15 years by Gayle Porter, a speech therapist with the Cerebral Palsy Education Centre in Victoria, Australia. PODD is an example of an assistive technology known as augmentative and alternative communication (AAC). It was created for all-the-time use. [16]

PODD can be customized and altered to suit a person of any age, and it could be considered for anyone who would benefit from using tools to enhance connecting with people, whether it's

comprehending language or assistance with it.

PODD is a method of organizing whole-word and symbol vocabulary in a communication book or speech-generating device to assist individuals who have challenging communication requirements in expressing themselves and understanding language.

The purpose of a PODD is to provide the vocabulary for use in a variety of contexts, with a variety of communications, and on a variety of subjects. It is intended to be an indispensable instrument in the toolbox for the communication methods' of the user. It is possible to select words and symbols in the PODD by pointing, gazing, or a combination of the two.

Everyday communication methods include speech, gestures, gesturing, facial expressions, and writing, and PODD chooses the most efficient approach for each situation. Similarly, a person with complex communication requirements may use a variety of communication methods, including a PODD, depending on what approach is most efficient for them at the time.

There are numerous varieties of PODDs, so the one used will depend on the individual's communication requirements. Each individual has unique communication preferences and skills. This is why various PODD formats are available, based on the physical, sensory, and interpersonal requirements of the particular user.

#### **Nine Words PODD :**

The nine-word PODD version is primarily intended for very young children to articulate their most fundamental communication needs. We delve deeply into the Nine Words PODD's structure. There are a total of fifty-one types of expression, which are spread across 117 pages. There is an "oops" button on each page, which indicates the user's inability to comprehend or convey something. In addition, there is a common button that leads to the essentials of daily life and a reverse button after two pages.

Some of the topics covered include:

- **Basic human communication:** This section includes words and pictures for common expressions, such as "hello," "goodbye," "please," and "thank you."
- **Daily activities:** This section includes words and pictures for activities such as eating, sleeping, dressing, and bathing.
- **Emotions:** This section includes words and pictures for a variety of emotions, such as happy, sad, angry, and scared.
- **Body parts:** This section includes words and pictures for different parts of the body.
- **Places:** This section includes words and pictures for different places, such as home, school, and the park.

- **Things:** This section includes words and pictures for different objects, such as toys, food, and clothing.

Now we talk about the distribution of the pages:

- **Page 1a:** Basic human communication, such as pointing to himself/herself, expressing a desire for more (could be a need for more or a desire to hear more of something, such as a story), expressing regret for making a mistake, completing a task, rushing for a task, expressing ignorance, seeking assistance, etc. Additionally, there are two icons that lead to the second page, which contains additional everyday expressions.
- **Page 1b:** The second page contains expressions involving emotional attachments such as sorry, please, thank you, excuse me, telling someone to stay away, saying goodbye, and a very essential daily need, the urge to use the restroom. In addition, his page contains a button that links to the menu function that will be covered in a later section.
- **Page 2a:** This page is similar to a menu that leads to various activities: Queries, Activites, Taste, and Telling about something. Going to a location, expressing dislike, displaying an object, performing a task, and if something is bothersome.
- **Page 2b:** This page contains some useful phrases for daily tasks, such as pointing to something inside, requesting the communicator, pointing to the bedroom, pointing to oneself, requesting the trainer to observe oneself, requesting the bag, and pointing to something new. This page contains two buttons that link to new pages; one is for requesting someone (a relative is acceptable) or pointing to a location.
- **Page 3:** All of the options on page 3 lead to page 7a, also known as the category page.
- **Page 4a - 4d :** This text on pages 4a through 4d helps children convey their feelings. These emotions include humorous, delicious, great, enjoyable, good, frightening, yucky, negative, foolish, naughty, and boisterous. Also included are negative and imperative expressions such as strive, not, clever, etc. Page 4d contains all the irritating expressions a child may encounter, such as dull, sad, mean, difficult task, wrong, cheeky, etc. In addition, if the child cannot locate the appropriate expression, the trainer will use a cyan-colored list button.
- **Page 5a :** This page discusses physical emotions such as sickness, anger, a health-related menu, pain, dislike, discomfort, fatigue, etc.
- **Page 5b :** Page 5b focuses on hunger and temperature-related expressions such as hot, chilly, and wet.

- **Page 6a -6b :** These two pages depict the body parts including the head, limb, arm, neck, back, and hand. Finger, abdomen, pelvis, mouth, eyes, nose, teeth, hair, ear, and tongue, among others.
- **Page 7a - 7c:** These three pages are the heart of the PODD books, as they are the main menu pages that are linked to all the other pages, which contain various categories such as: pointing to people, daily activities, school stuffs, special ceremonies and events, days and time, places, clothes, health, transportation, emotions, animals, house and gardens, fictional characters, questions, foods, religion, alphabet, body parts, etc.
- **Page 8a - 8b :** These two pages are for questions such as Yes or no, where, no, why, whom, what, who, how, what's your name, how are you, and what's next, among others.
- **Page 9a - 9c :** These pages contain references to people, primarily relatives or school-related individuals such as the author, his or her sibling, and sister. mother, grandfather, grandmother, school personnel, father, baby, aunt, uncle, personal care attendant, teacher, partner, and closest friend, among others.
- **Page 10a :** This page contains several unrelated random expressions, including not, buy, like, do, give, see, look, and speak, among others.
- **Page 10b :** This page contains positional references such as in, out, place, on, off, and take.
- **Page 10c :** This page describes activities involving tangible objects, such as a box. This page contains commands such as want, go, open, close, come, have, obtain, and produce, among others.
- **Page 10d - 10e :** These two pages contain a variety of exercises, such as squat, roll, bend, stand, crawl, stretch, walk, lie down, push, catch, and grasp. Pull, toss, lower, tumble, etc.
- **Page 11a - 11f:** This subcategory contains six pages. There are solitary buttons and buttons that lead to other categories on each page. The majority of these pages pertain to daily activities, such as eating, making, playing, cuddling, resting, reading, watching television, dressing up, listening to music, using a computer, solving puzzles, drawing, painting, cooking, and playing outside on a trampoline, sandpit, playground, swing, climbing frame, slide, see saw, etc.
- **Page 12a - 12c:** These pages are about the outside places a child would adore to visit, such as shops, a car ride, a swimming pool, a movie, a zoo, a park, a library, a beach, McDonald's, a supermarket, a shop, a restaurant, a video store, etc.

- **Page 15a - 13c:** This category contains birthday, card, party, present, happy, invitation card, Santa Claus, Christmas, holiday, easter bunny, easter egg, prize, haircut, father's and mother's day, fair, dining out, sleepover, etc.
- **Page 14a - 14e:** These pages contain health-related terms such as doctor, appointment, hospital, dentist, ill, better, rash, pain, wound, bleeding, cold, vomit, cough, diarrhoea, sneeze, and constipation. need, bandage, medication, injection, chemist, ointment, exam, test, plaster, x-ray, stethoscope, etc.
- **Page 15a - 15c:** This category consists of pages 15a to 15c and discusses clothing and clothing-related activities such as putting on, taking off, and changing. Dresses including shoes, trousers, sweater, socks, shorts, top, tracksuit, coat, jacket, pajamas, gown, hat, gloves, and skirt, among others.
- **Page 16a - 16c:** These pages include items such as batteries, bags, prizes, photos, money, umbrellas, cameras, decals, mobile phones, tissues, switches, displays, and communicators.
- **Page 17a - 17e:** This category includes kitchen, living room, bathroom, bedroom, door, window, floor, laundry, chair, table, heater, light, air conditioner, stairs, telephone, letter box, garbage can, gate, garage, barbecue, water, tree, garden, flower, grass, lawn, mow, weed, etc.
- **Page 18:** This document lists common expressions, including more, hurry up, wait, complete, drink, yummy, yucky, and dislikes. These expressions are common in commonplace speech and can aid in comprehension and communication with others.
- **Page 19a - 19b:** Page 19a- 19b contains images of vehicles and related objects, including a fly, motorcycle, truck, aircraft, boat, fire truck, helicopter, train, rash, beep, bus, etc.
- **Page 20a - 20b:** Here, fictional characters such as monster, jester, fairy, and toothfairy are depicted.
- **Page 21a - 21c:** These three pages include animal-related verbs such as see, gaze, feed, pat, and vet, as well as the names of various animals.
- **Page 22a - 22c:** This section of the book discusses time-related concepts such as now, later, later, today, tomorrow, tonight, yesterday, day, night, morning, noon, afternoon, shortly, holiday, time, clock, the names of the seven days of the week, etc.
- **Page 23a - 23b:** These two pages discuss numerous emotions, including happy, worried, and feel. Feelings such as embarrassment, confusion, love, hatred, anger, fear, pride, frustration, sadness, loneliness, envy, etc.

- **Page 24a:** This page serves as a portal to all the other pages on page 24.
- **Page 24b - 24c:** It describes a thing using adjectives such as new, rapid, same, old, slow, different, youthful, loud, noisy, dead, broken, quiet, alive, repaired, etc.
- **Page 24d:** Displays various hues, including red, pink, black, yellow, orange, etc.
- **Page 24e:** Page 24e displays various shapes including rectangle, heart, circle, triangle, star, square, and diamond, among others.
- **Page 24f:** Compares various sizes, including large, tall, fat, small, short, thin, tiny, and long, among others.
- **Page 24g:** It shows different quantities such as most, all, few, many, some, less, more etc.
- **Page 24h :** Shows all the digits starting from 1 to 10.
- **Page 24i:** Describes physical sensations such as soft, heated, moist, hard, cold, dry, sticky, and rough.
- **Page 24j:** Depicts various culinary tastes, including sweet, delicious, yummy, sour, salty, unpleasant, and spicy, among others.
- **24k:** Indicates the appearance of an object, such as complete, shiny, spotless, empty, dull, or dirty.
- **Page 25a - 25e:** This section of the book discusses school-related activities and items, such as lunch time, leisure, reading, mathematics, the library, writing, sport, art, the computer, music, the classroom, staffroom, playground, canteen, office, hall, restroom, sick-bay, uniform, lunchbox, reader, hat, drink bottle, schoolbag, and homework, among others.
- **Page 26a - 26b:** These two pages illustrate religious expressions and their respective religious institutions.
- **Page 27:** Page 27 discusses activities while viewing television, such as adjusting the volume, selecting a favorite channel, turning the television on or off, etc.
- **Page 28:** This page contains information about books, such as lifting the flap, rotating the page, viewing an image, and reading again.
- **Page 29, 30, 31 :** These pages pertain to game-related terms such as turn, win, roll, squash, play dough, cut, squeeze, and create, among others.
- **Page 32, 33, 34:** These three pages pertain to drawing-related topics, including paper, draw, cryons, finger, colors, assistance, finish, glue, and sticking down.

- **Page 35:** This page contains cooking-related expressions such as more, cook, is it ready, stir, yummy, and want to sample.
- **Page 36:** This document discusses playing with building blocks on page 36.
- **Page 37:** This page includes expressions such as where, place, finished, fit together, puzzle piece, turn around, and joy moment in relation to playing with puzzles.
- **Page 38a - 38d:** These pages are intended to assist the child with daily hygiene, such as changing the diaper, giving the doll a bath, washing, bathing, splashing, getting soaked, water, drying, soap, cleaning, nappy, wiping, stinky, poop, and using baby powder. It also includes sleep time activities such as good night, putting on the covers, desiring the baby doll, sleeping, rocking in a chair, kissing and cuddling, waking up, and singing lullabies, among others.
- **Page 39, 40, 41:** These three pages pertain to playing activities such as fast, push, road, blow, bubbles, popping a bubble, hurl, bounce, and catch, among others.
- **Page 42:** This article contains information about construction and craft tools such as hammer, nail, saw, wood, drill, etc.
- **Page 43:** This page describes water-related activities that children play, such as boat, slash, and wet.
- **Page 44:** This page discusses various dress-up-related activities, such as gazing in the mirror, putting on a shirt, being prepared, and wearing jewelry.
- **Page 50:** This page tells about the activities and stuffs after the baby uses the bathroom like clean, nappy, lie down, wet, bottom, wipe, poop, cream, finished, toilet paper, nothing is coming etc.
- **Page 51a - 51f:** This is the last section of the PODD book and shows all the alphabets.

The Nine Words PODD is a valuable aid for individuals with communication difficulties. It can help them articulate their needs, desires, and emotions in a clear and understandable manner. The book is also an excellent method for individuals with disabilities to learn new words and ideas.

## 3.6 Development Steps of e-PODD

We have created an electronic version of this cumbersome book for your convenience. This particular version of the app is capable of running on any Android device, whether it be a

smartphone or a tablet. Even if it is recommended to use a tablet, it is perfectly acceptable to operate the application on a mobile phone.

#### **Minimum requirements:**

- Android [17] version : 7.0
- Screen size : 6 inches
- Storage: 21 MB

Now we will discuss the reasons why an electronic version needs to be created.

It is difficult to transport the PODD book because of its large size and weight. Additionally, PODD is an icon-based organization system [7]. The youngster needs to be instructed by a trainer on how to utilize the book [18]. When a child points to an icon, there is always the possibility that the child has pointed to an icon that leads to another icon that is located on another page on the PODD book. In this scenario, the child has pointed to an icon that leads to another page. Without a doubt, the instructor is going to require some time to browse through the book. In the interim, it's possible that the child will forget what it was that he or she wanted to say. Because of this, the expression might not be understood.

If, on the other hand, the electronic version is utilized, then the engagement will be impromptu due to the fact that the interface will be touch-based. As a direct consequence of this, the child will have an easier time expressing himself or herself.

### **3.6.1 Advantages of an Electronic Version**

#### **Ease of use for the electronic version:**

Depending on the specific requirements and preferences of the user, consulting an electronic version of the PODD can provide a number of benefits that a physical book cannot. The following is a list of potential advantages of utilizing the electronic version:

- **Portability:** The electronic versions of PODD are particularly portable because they can be placed on a variety of devices, such as tablets and smartphones. This eliminates the need for people to carry around a physical book and instead enables them to have their communication system easily available wherever they go.
- **Adaptability and personalization:** in comparison to physical books, electronic editions typically offer a larger degree of adaptability and personalization options. Users are able to change and customise the communication system by modifying the terminology, changing the layout, adding or removing icons, and so on, to better suit their own requirements and preferences.

- **Enhancing Communication:** Electronic PODD systems have the ability to add dynamic content, which may include films, audio recordings, or interactive elements. These features of multimedia have the potential to improve communication by supplying extra means of expression and rendering the system more interesting and interactive.
- **Capabilities for searching and navigating:** The majority of the time, electronic versions come with search and navigation capabilities that make it simpler to find particular words or phrases that are contained inside the communication system. This can be of great assistance to people who require a large vocabulary or who wish to fast access particular topics.
- **Updates and Backups:** Easier system updates and backups Having the information stored in an electronic format makes it much simpler to perform system upgrades and backups. It is possible to add new symbols, terminology, or features, and adjustments can be made in a more time-efficient manner. In addition, electronic systems can be backed up, which safeguards against the possibility of destroying or losing physical materials.

Not only that, but prior to the creation of the one we created, PODD had a digital version. The acronym stands for "simPODD [11]." However, simPODD is only compatible with iOS handheld devices, which aren't used all that frequently in Bangladesh. mainly due to the fact that only 4.06% of the population in Bangladesh uses iOS devices [19]. Because of this, utilizing simPODD in Bangladesh will not be an option that is viable. In addition, simPODD is a paid service [11].



Figure 3.2: A child using simPODD [Source: <https://www.assistiveware.com/products/simpodd>]

Now, we will discuss how we created our version of PODD for android [17].

It is important to note that our implementation of PODD gathers data, which consists mostly of the child's button presses and releases. It is possible to be entirely anonymous. It is going to be employed in the future for evaluating behavior and interaction patterns, and it will be used in the future. While using PODD book during training, the trainer is the only person who can manually assess the interaction pattern and the behavioral pattern that the child displays.

However, the data that is collected in the e-PODD is gathered in such a way that it makes it simple to monitor the behavior. This is the format in which the data is gathered:



Figure 3.3: Data Collection Format

This format will be helpful for us in the future when we are performing analysis on the data that was obtained. The name of the page as well as the name of the symbol will provide the essential mapping for the expression, and the duration will tell us how much time the child needs to spend interacting with the icons. A better understanding of the concept will result from looking at this picture.

```

Page 1a : Go to Next Page : duration 5267miliseconds
Page 1a : Go to Next Page : duration 4097miliseconds
Page 1a : Go to Next Page : duration 3084miliseconds
Page 1a : Go to Next Page : duration 4534miliseconds
Page 1a : Go to Next Page : duration 2008miliseconds
Page 1a : Go to Next Page : duration 6159miliseconds
Page 1b : Go to Toilet 50 : duration 2520miliseconds
Page 1b : Go to Page 1 : duration 6547miliseconds
Page 1a : Go to Next Page : duration 1809miliseconds
Page 1b : Go to Categories 7 : duration
1391miliseconds
Page 1a : Go to Next Page : duration 2405miliseconds
Page 1b : Go to Page 1 : duration 1709miliseconds
Page 1a : More to Say : duration 1077miliseconds
Page 1a : Go to Next Page : duration 1462miliseconds
Page 1b : Go to Page 1 : duration 5410miliseconds
Page 1a : More to Say : duration 689miliseconds
Page 2a : I'm asking a question : duration
1618miliseconds
Page 2a : I want to do an activity : duration
4462miliseconds
Page 2a : Let's go 12 : duration 6531miliseconds
Page 2a : I don't like this 4c : duration
9040miliseconds
Page 1a : More to Say : duration 15007miliseconds
Page 2a : I'm telling you something 3 : duration
6453miliseconds

```

Figure 3.4: Collected Data

According to the statistics that were gathered, the first two subjects, which are the page name and the icon name, will assist us in tracking the behavior and movement of the button, and the duration on the page will assist us in tracking the amount of time that the child needs to spend interacting with the app. If we evaluate the data and notice a downward trend in the amount of time spent interacting with the system, we will be able to deduce that the child is spending less time using e-PODD, which indicates that the learning process is accelerating.

Now we dive into the app. When the app is opened it asks for storage permission.

After acquiring the permission, this software starts to collect the data in the background while delivering uninterrupted interaction to the user. The interaction is fluent as it is touch based. There is no latency or problems in the app. The app saves the data in the local storage. The data is kept safe from the user so that the user can't access the data. If the user can access the data, there's a potential that the user might erase it.

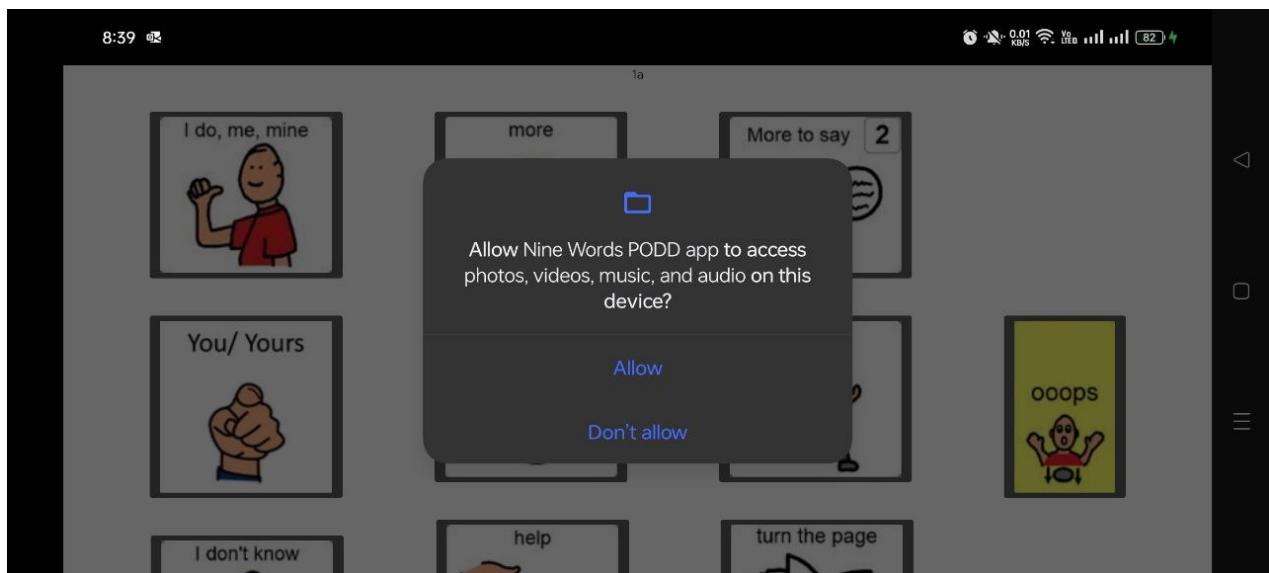


Figure 3.5: Data Permission

Now let's look at the UI of the app.

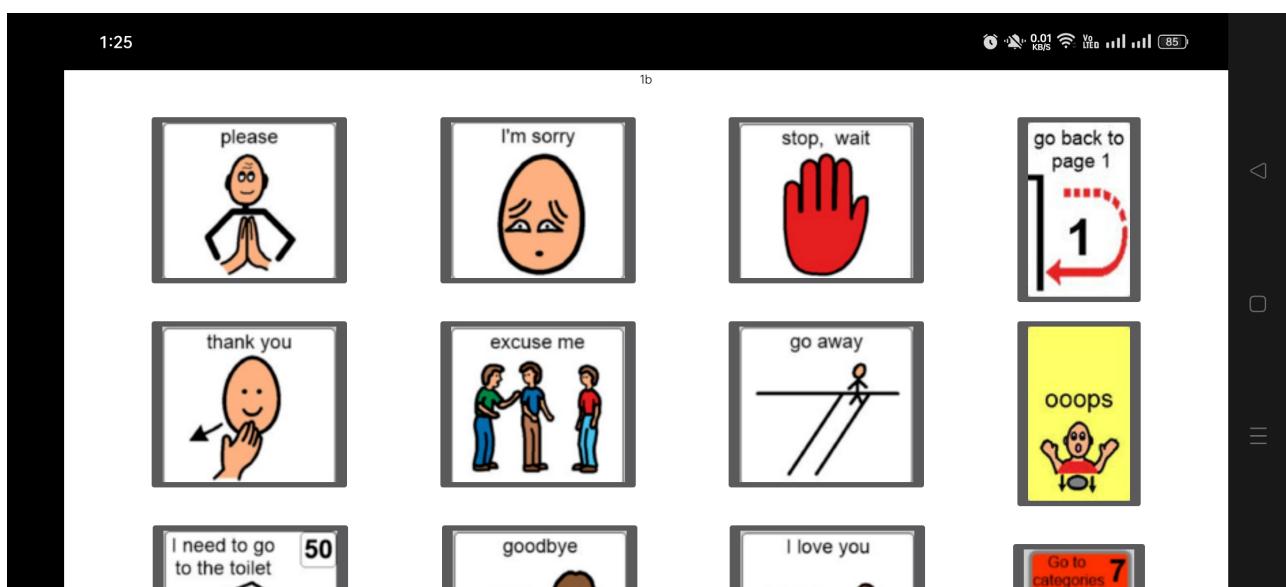


Figure 3.6: App UI in an Android Smartphone

Also let's look at the original book.

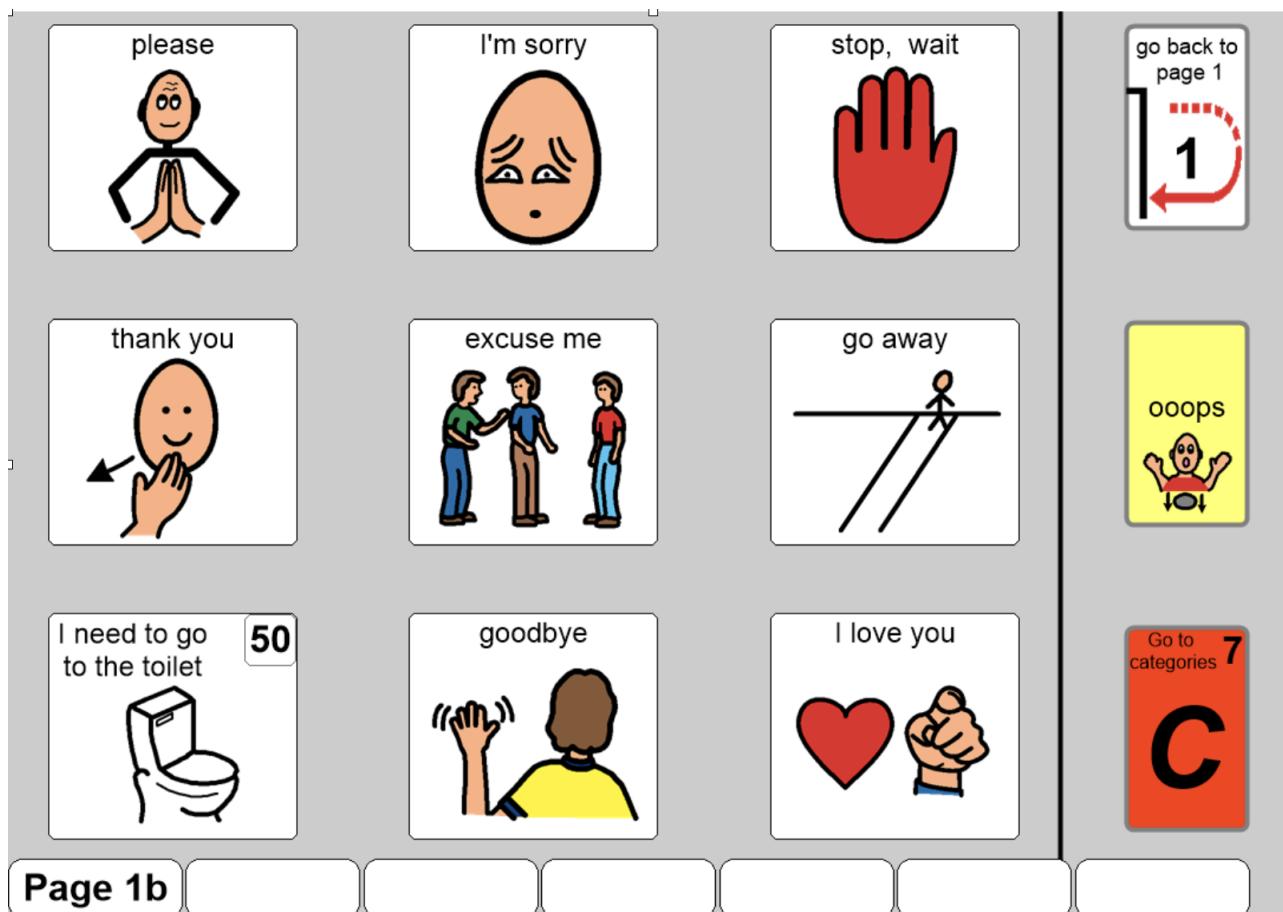


Figure 3.7: Original PODD Book

Therefore, it is evident that we haven't changed the app's design in any way. It functions precisely how the original PODD book was intended to, including pointing to an icon and linking the icons using the same mapping.

The nine words PODD book also has a Bengali text version that we have produced. We translated the words while keeping all the iconography the same. Although we didn't translate it literally, we did so in the best appropriate way.

Here's is a glimpse of the Bengali version App.

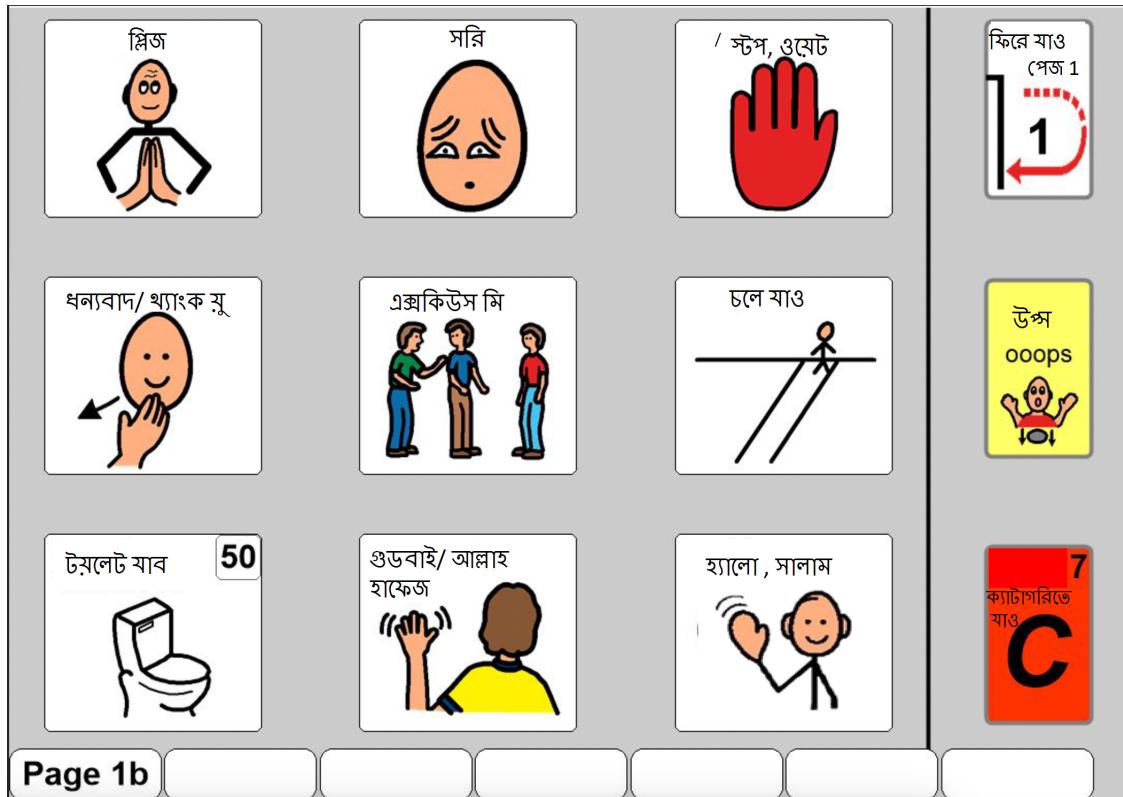


Figure 3.8: Bengali PODD App

Now we talk about some technical challenges that we faced while building the app.

### 3.6.2 Technical Challenges

#### Adapting to the screen size

During the process of designing the app, this was one of the most difficult aspects. since our application is designed to work on a variety of Android devices, including smartphones, tablets, and so on. During the process of developing the app in Android Studio [20], we had to go through a lot of trial and error to figure out how to incorporate the icons in the most effective way. Fixing the size of the icons to a size that is compatible with all of the devices was a difficult challenge. The sizes of the icons could not be reduced or increased to extremes. If the icons were too small, it would be difficult for the children to make out the instructions that are associated with the icons. If the icons were too big, a single page would not fit on a device with a smaller screen, such as a smartphone. Therefore, when we were developing the app, we made sure that the screen would be suitable for both smartphones and tablets by adjusting the size of the icons. Even though the user interface of the mobile device requires a little bit of scrolling, it is fully usable. When you open a tab, you will get a large full screen. Therefore, the issue with the screen size was resolved by a great deal of trial and error.

## File Handling

In order to handle the file management, we decided to make advantage of the Singleton design pattern [21]. A design pattern known as the singleton pattern makes certain that a class has only one instance and offers users a single point of access to that object worldwide. The Singleton pattern is versatile and may be applied in a variety of contexts, such as the management of database connections. [21].

When the app is installed and opened for the first time a prompt pops on the screen that tells the user to give a local storage permission. When the app is used it starts tracking the button movements and appending all the touch information in a .txt file that is saved into the internal storage of the android device.

Now we look at the diagram of the singleton class called **FileUtils**.

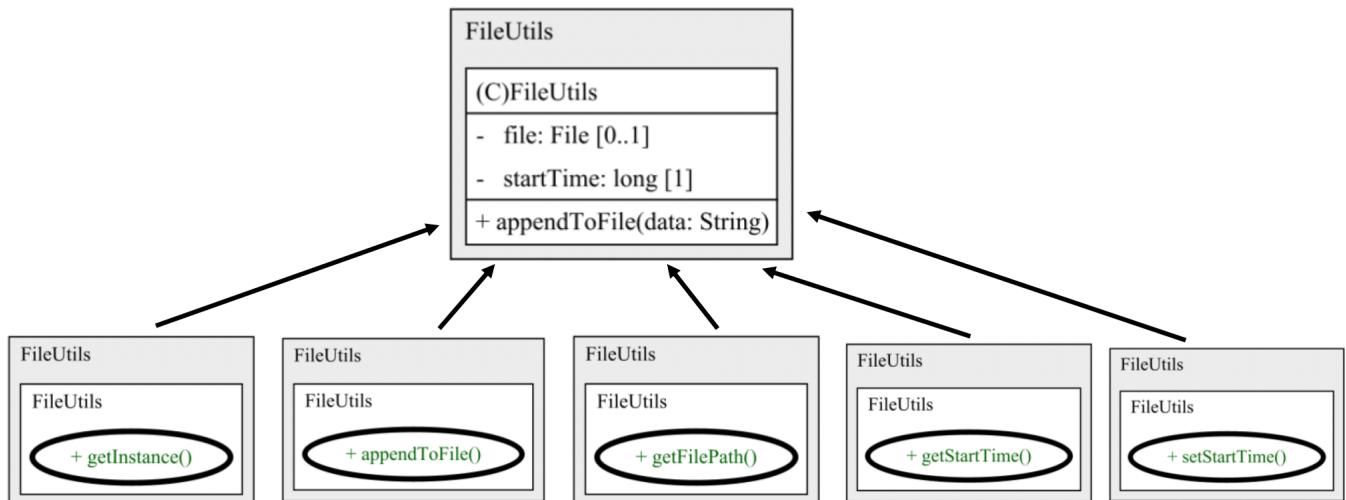


Figure 3.9: Singleton Structure

This 'FileUtils' class is a utility class that manages file operations in some capacity, as the diagram describes it. The following is a rundown of the functions that this class performs:

- Imports: The file begins with all of the relevant import declarations already present.
- Class Definition: The 'FileUtils' class has been formally outlined.
- Constants: It is necessary to define two constants:
  - The 'FILENAME' variable is used to specify the name of the text file.
  - The 'DIRECTORYNAME' parameter is used to specify the name of the directory in which the file will be saved.

- Member Variables: The 'startTime' variable is a long variable that stores the start time of the page activity.
- Singleton Pattern:
  - 'instance' is a static member variable of the class 'FileUtils' that stores the class's singleton instance. 'FileUtils' is an acronym for the class File Utilities.
  - 'private FileUtils()' is a private constructor that ensures the singleton design pattern is followed by preventing the class from being instantiated from anywhere other than within the class itself.
  - 'getInstance()' is a public static method that returns a single instance of the class and is considered to be the class's singleton. It uses a method known as lazy initialization, which means that the instance is only created if it doesn't already exist.
- The 'getFile()' method is a private function that either retrieves an existing file object or generates a new file object based on the directory and file name that are provided. It obtains the external storage directory by calling the method 'Environment.getExternalStoragePublicDirectory()', and then it appends the directory and file name that are wanted to the directory that is obtained. The 'mkdirs()' function is used to create the directory if it does not already exist.
- The 'appendToFile(String data)' method is a public method that appends the 'data' string that has been provided to the text file. It first opens the file using the 'FileOutputStream' program in append mode, then it makes a 'OutputStreamWriter', writes the data to the file, and finally it shuts the writer.
- A public method called 'getFilePath()' that returns the file's complete path in absolute format.
- The 'startTime' variable has public getter and setter methods called 'getStartTime()' and 'setStartTime(long startTime)' respectively.

In general, this class makes it easy to manage file operations, specifically the process of writing data to a text file in an Android application by providing a handy way to do it. The 'getFile()' method is responsible for both the generation of new files and their subsequent retrieval. The singleton pattern makes sure that there is only ever one instance of the 'FileUtils' class. The 'appendToFile()' method makes it possible to add new information to a text file, and the 'getFilePath()' method returns the absolute path to the file.

A structure of code like this ensures that every action is logged from the very first touch and prevents the file from being overwritten.

### Avoiding redundancy

We have used the concept of Inheritance [22] to avoid some redundancy. The mapping and the pages are designed in the PODD book has so many mappings to do with the pages and the icons. We have used concept of inheritance to avoid redundancy.

Here is the diagram:

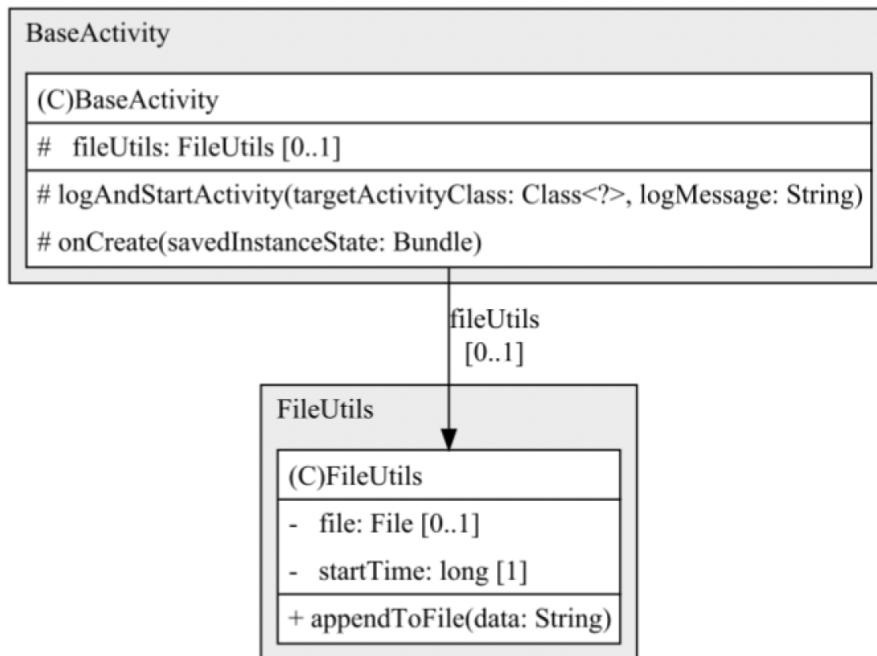


Figure 3.10: Usage of Inheritane to Avoid Redundancy

Redundancy is decreased in the code in a number of ways by using this structure:

- **Code reuse:** Several subclasses can make use of the `BaseActivity` class's shared features. In this instance, the base class only implements the `logAndStartActivity` function once, allowing any subclass to call it without implementing it themselves.
- **Centralized Logic:** The `logAndStartActivity` function of the `BaseActivity` class centralizes common actions like logging and initiating activities. By doing so, consistency between activities is ensured and duplicate logic is avoided.

This is how we achieved the code base to be small enough. The app is only 21 MB which is significantly small.

### 3.6.3 Limitations of PODD

PODD is an extensively utilized and highly regarded communication system, but it has some limitations. Here are some potential disadvantages of PODD:

- Initial configuration and customization: The implementation of a PODD system requires careful customization to meet the unique requirements of the user. This procedure can be lengthy and may necessitate the assistance of a speech-language pathologist or communication specialist.
- Depending on the scale and complexity of the PODD system, it may be difficult to transport. Some versions of PODD include large binders or volumes, which may be inconvenient for those who need a more compact communication solution.
- While PODD provides a variety of vocabularies, there may be restrictions on the specific words and phrases that can be used. It may be difficult for users to express certain concepts or employ specialized terminology that is not included in the PODD system.
- Both the user and their communication companions are required to learn and comprehend the PODD system. This may entail understanding the structure of the communication pages, their symbols, and how to effectively navigate the system. Everyone involved may require time and practice to become proficient with PODD.
- It is crucial to note that the effectiveness and limitations of PODD can vary based on the person using it and the level of support and training they receive. Working closely with a speech-language pathologist or communication specialist can assist in addressing specific concerns and optimizing the use of PODD for each individual's particular requirements.
- Regarding customization, there are options for tailoring PODD systems to individual requirements. Blank pages or icons allow for customization, as symbols or words can be added based on the user's essential vocabulary or concepts. This adaptability is advantageous for customizing the system to individual preferences and needs.
- In addition, having the capacity to enlist things based on an individual's requirements adds an additional level of customization. This enables users to include specific individuals, locations, or objects in their communication system, making it more pertinent and meaningful to their daily lives.

#### **Redundant usage of icons in PODD**

However, it is essential to keep in mind that pre-built communication systems such as PODD are designed with the intention of being all-encompassing and accommodating a diverse group

of end users. The goal is to provide a foundation of frequently recognized and used symbols and words that can be accessible by a wide variety of people in a way that is convenient for them. By taking this approach, all users of the system will experience a certain level of consistency as well as a sense of familiarity.

Through customisation, it is possible to reduce, if not completely eliminate, the redundant use of icons. PODD systems can be personalized and updated to include more icons or remove redundant ones based on the specific requirements and preferences of the user, as I indicated previously. This can be done by adding or removing icons from the system. Users are given the ability to simplify their communication system and give greater weight to the icons that are most pertinent to them by virtue of this modification.

In the end, the efficacy of any communication system, including PODD, is determined by the individual user's comfort level, knowledge with the system, and capacity to communicate oneself using the icons and terminology that are accessible. By collaborating closely with a speech-language pathologist or communication professional, an individual can have any unnecessary icons pointed out to them, and any necessary alterations to the system can be made to better accommodate their communication requirements.

# Chapter 4

## Future Works

Here are a few potential prospective research areas:

- **Cloud Integration:** At the present time, the data is only kept in a local storage that, in the future, will be able to be transferred to the cloud and kept in a centralized database. It is possible to utilize it for analyzing a child's behavior as well as monitoring the child's performance in adjusting to the app and measuring the child's progression along the learning curve.
- **Symbol recognition:** Developing ML models for symbol recognition could aid in the automatic identification and classification of PODD symbols. Automatically assigning pertinent symbols to specific vocabulary or concepts could streamline the process of customizing and personalizing PODD systems.
- **Natural language processing (NLP):** NLP techniques can be used to improve PODD's language processing abilities. ML models could be trained to interpret and comprehend natural language inputs, enabling users to generate messages using speech or text that could then be translated into the corresponding symbols or iconography within the PODD system.
- **Adaptive and individualized systems:** ML algorithms could be used to develop adaptive and individualized PODD systems. These systems could learn from user interactions and evolve over time, altering the organization, vocabulary, or symbol selections based on the user's preferences, usage patterns, and communication requirements.
- **Usage of Machine Learning:** PODD systems can utilize ML models to incorporate context-awareness. By taking into account the user's environment, activity, or specific context, the system can provide more pertinent and context-appropriate vocabulary suggestions, thereby enhancing the efficiency and effectiveness of communication.

- **User feedback and evaluation:** ML can aid in collecting and analyzing user feedback and utilization data in order to evaluate the efficiency and usability of PODD systems. This can assist in identifying areas for enhancement, optimizing symbol selection, and informing ongoing development and personalization efforts.

Notably, incorporating ML techniques into PODD would necessitate the collection and annotation of massive datasets of symbol images, linguistic data, and user interactions. It would be beneficial to collaborate with experts in machine learning and human-computer interaction to assure the development of efficient and user-centric ML approaches for PODD.

These are only a few possibilities for enhancing PODD with ML. Exploring these avenues would necessitate inter-disciplinary collaboration and ongoing research and development efforts to create more sophisticated and individualized communication systems for people with complex communication requirements.

# **Chapter 5**

## **Results**

We evaluated the app with a group of children with autism. The results showed that the app was easy to use and that it helped the children to communicate more effectively.

The children were able to use the app to communicate their needs and wants, and to interact with others. They also reported that they liked using the app.

The study aims to develop vocalization-enhancing and expression-enhancing technology using an Android app interface to better understand the goals of people with nvASD (non-verbal autism spectrum disorder) and mvASD (minimally verbal autism spectrum disorder) and facilitate communication between them and the general public.

In order to help people by improving communication for individuals with non-verbal or minimally-verbal autism spectrum disorder (nvASD or mvASD) by utilizing an Android application interface, we seek to identify expressions and develop new tools.



Figure 5.1: Seminar on PODD

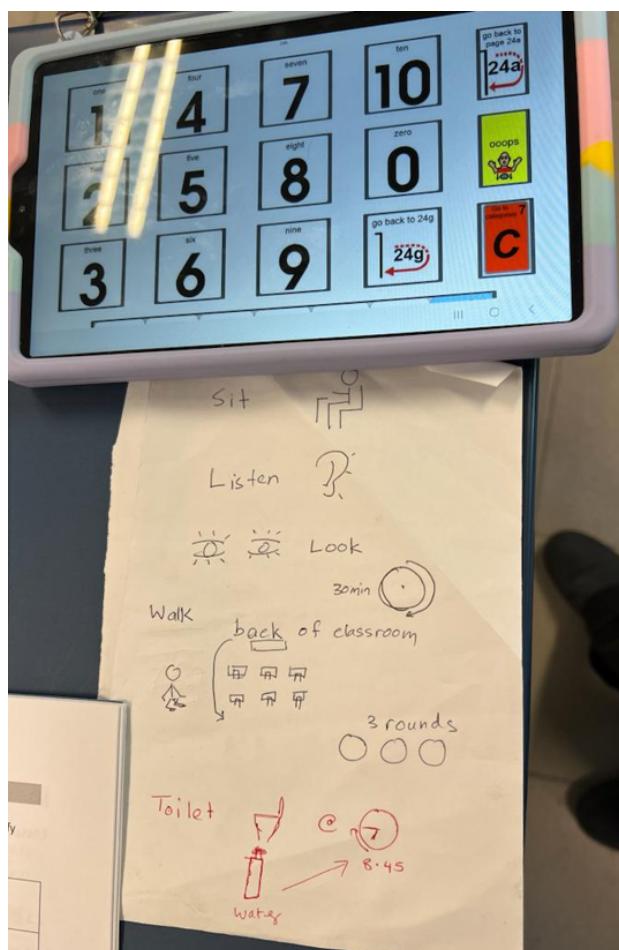


Figure 5.2: Training on PODD



Figure 5.3: Training on our e-PODD

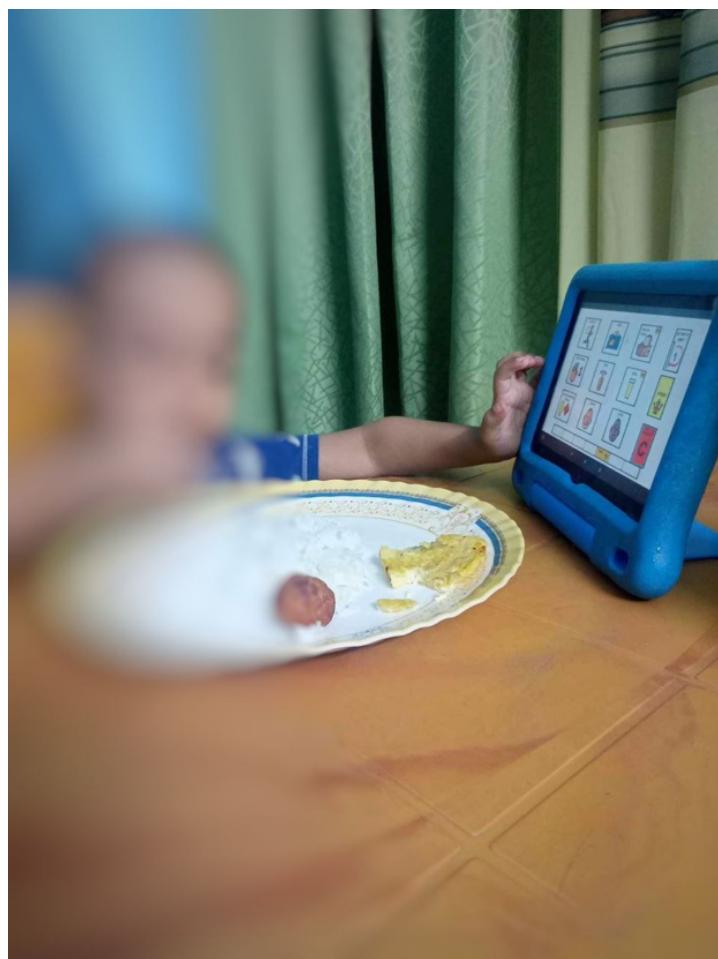


Figure 5.4: A Child Using Our e-PODD

# **Chapter 6**

## **Conclusion**

The development of an Android app for PODD is a significant step forward in the development of communication tools for people with autism. The app is easy to use, effective, and versatile. It is a valuable tool for people with autism and their families. The ultimate goal of this effort is to provide new ways to understand the vocalization and expression intent of nvASD or mvASD individuals and improve communication by creating a bridge between them and the general public who do not use traditional spoken communication words.

We now, enlist our contributions to this research as follows:

- give background information on the works pertinent to improving communication for nvASD or mvASD individuals;
- design and implement an interface for use by caregivers in understanding the expression and vocalization of nvASD or mvASD individuals;
- compare the working procedure of different apps which are all paid and develop the most efficient and free Android app which is very memory and time efficient.

# References

- [1] “Avaz app.” <https://avazapp.com/>. Accessed: 2023-05-14.
- [2] “ASD definition.” <https://www.nimh.nih.gov/health/topics/autism-spectrum-disorders-asd#:~:text=Autism%20Spectrum%20Disorder-,Overview,first%202%20years%20of%20life.> Accessed: 2023-05-14.
- [3] “nvASD and mvASD, howpublished = <https://www.ncbi.nlm.nih.gov/pmc/articles/pmc7377965/>, note = Accessed: 2023-05-14.”
- [4] “ASD in bangladesh.” <https://cri.org.bd/2014/09/03/global-autism-movement-and-bangladesh/>. Accessed: 2023-05-14.
- [5] C. M. R. R. L. C. M. A. S. H. A. S. M. Lieutenant Colonel Md Fakhrul Alam1, Israt Jahan, “A study on autism in bangladesh: Current scenario and future prospects and challenges,” *Scholars Journal of Applied Medical Sciences*, pp. 1–7, 2020.
- [6] “mnASD verbal condition.” <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3869868/>. Accessed: 2023-05-14.
- [7] “PODD developed by.” [http://podd.dk/eu-wp/?page\\_id=33](http://podd.dk/eu-wp/?page_id=33). Accessed: 2023-05-14.
- [8] “PODD is effective.” [https://www.researchgate.net/publication/272013822\\_Use\\_of\\_iPadiPods\\_with\\_Individuals\\_with\\_Autism\\_and\\_other\\_Developmental\\_Disabilities\\_A\\_Meta-analysis\\_of\\_Communication\\_Interventions](https://www.researchgate.net/publication/272013822_Use_of_iPadiPods_with_Individuals_with_Autism_and_other_Developmental_Disabilities_A_Meta-analysis_of_Communication_Interventions). Accessed: 2023-05-14.
- [9] “PODD is effective (2).” [https://www.researchgate.net/publication/359844532\\_Social\\_Skills\\_Communication\\_and\\_Autonomy\\_in\\_Children\\_with\\_Autism](https://www.researchgate.net/publication/359844532_Social_Skills_Communication_and_Autonomy_in_Children_with_Autism). Accessed: 2023-05-14.
- [10] “PODD is effective (3).” [https://www.researchgate.net/publication/325914641\\_Effects\\_of\\_Interventions\\_That\\_Include\\_Aided\\_](https://www.researchgate.net/publication/325914641_Effects_of_Interventions_That_Include_Aided_)

- Augmentative\_and\_Alternative\_Communication\_Input\_on\_the\_Communication\_of\_Individuals\_With\_Complex\_Communication\_Needs\_A\_Meta-Analysis. Accessed: 2023-05-14.
- [11] “simPODD ios app.” <https://www.assistiveware.com/products/simpodd>. Accessed: 2023-05-14.
- [12] “ASHA.” <https://pubs.asha.org/doi/10.1044/aac18.4.121>. Accessed: 2023-05-14.
- [13] “MITA app.” <https://www.mdpi.com/2227-9032/8/4/566>. Accessed: 2023-05-14.
- [14] “Speech Blubs app.” <https://speechblubs.com/>. Accessed: 2023-05-14.
- [15] “Wheel of emotion.” <https://www.toolshero.com/psychology/wheel-of-emotions-plutchik/>. Accessed: 2023-05-14.
- [16] “Podd communication tools.” [https://novitatech.com.au/podd-communication-tools/](https://novitatech.com.au/podd-communication-books/).
- [17] “android android - secure & reliable mobile operating system.” <https://www.android.com>. Accessed : 2023-05-20.
- [18] “How to use podd.” <https://secure.toolkitfiles.co.uk/clients/40156/sitedata/files/PODD-Communication.pdf>. Accessed : 2023-05-20.
- [19] “ios apple market share.” <https://gs.statcounter.com/os-market-share/mobile/bangladesh>.
- [20] “Meet android studio.” <https://developer.android.com/studio/intro>. Accessed : 2023-05-20.
- [21] “Singleton.” <https://refactoring.guru/design-patterns/singleton>. Accessed : 2023-05-20.
- [22] “Oop inheritance.” [https://www.w3schools.com/php/php\\_oop\\_inheritance](https://www.w3schools.com/php/php_oop_inheritance). Accessed : 2023-05-20.

Generated using Undegraduate Thesis L<sup>A</sup>T<sub>E</sub>X Template, Version 2.2. Department of Computer Science and Engineering, Bangladesh University of Engineering and Technology, Dhaka, Bangladesh.

This thesis was generated on Thursday 15<sup>th</sup> June, 2023 at 4:01am.