A Comprehensive Study on Innovative AAC Solution for Enhancing Communication in Speech-Impaired Children

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Augmentative and Alternative Communication (AAC) systems serve as crucial communication tools for children who face speech and language difficulties. This paper outlines the design and development of an AAC mobile application specifically tailored to address the communication needs of children, allowing them to effectively express their thoughts and feelings. The app is created with the flexible Flutter framework and Visual Studio Code. Key features include symbol-based communication, text-to-speech, customizable symbols, and voice output, all suited to the specific requirements of speech-impaired youngsters. The user-friendly design emphasizes accessibility with vivid iconography for increased interaction. The software is evaluated in the paper using user satisfaction measures, real-world usage in educational contexts, and visual input from user interactions. A comparative analysis with existing AAC apps highlights the strengths of the proposed solution. The conclusion emphasizes the crucial role AAC apps play in aiding communication for children with hearing impairments. Future improvements include real-time capabilities, advanced feature extraction, and collaborative elements for user-caregiver communication, aiming to advance accessibility and efficacy in communication tools for this user group. This research contributes significantly to enhancing communication tools for children with speech impairments.

Keywords: Speech therapy, Text-To-Speech, Personalized Communication Apps, Children with Speech Difficulties, Augmentative and Alternative Communication (AAC).

Introduction:

The ability to communicate is essential to human existence, yet many youngsters struggle because of speech and language disorders. Alternative forms of expression are provided via Augmentative and Alternative Communication (AAC) technologies. As accessible AAC alternatives, smartphone applications have recently surfaced, facilitating digital venues for communication. The creation of an AAC app for kids with speech impairments is examined in this article, with an emphasis on features and design that improve accessibility and use. AAC is a common way for kids with special needs to express themselves. Disorders including Down syndrome, autism, cerebral palsy, and other developmental disorders can impair verbal communication, which can have an impact on social interaction, academic achievement, and personal development. When conventional approaches are inadequate, AAC offers these kids alternate means of expressing their wants, feelings, and thoughts using gestures, visual symbols, and speech-generating instruments. The significance of AAC is highlighted by the realization that meaningful contact and communication go beyond speech, particularly in educational contexts where communication is essential to participation and learning.

AAC is necessary when it is acknowledged that communication is more than simply speaking; it also entails interacting with others and expressing thoughts and feelings. These skills are frequently lacking in children with speech and language impairments. This disparity is particularly noticeable in learning environments, where peer contact and communication are essential. Through successful communication, AAC devices give these kids access to social and educational possibilities. Technological advancements have facilitated the creation of advanced AAC solutions. These range from low-tech options like communication boards with visual aids to high-tech devices equipped with text-to-speech capabilities. The rise of mobile applications has revolutionized AAC by making these tools more accessible, portable, and customizable. The goal of this project is to create a mobile AAC application for kids who have trouble speaking, particularly those who speak Pashto and Urdu. Even young children and those with severe impairments may utilize the app's user-friendly communication tool, which combines text-to-speech, visual symbols, and adjustable options. The project's objective is to provide an accessible, reasonably priced solution that will improve quality of life, increase user independence, and eliminate obstacles to communication. This essay investigates the features, technological advancements, and possible effects of the app on kids with speech problems.

We identified communication difficulties for children with speech problems and assessed available mobile AAC options. This article discusses design considerations, implementation details, and a comparative usability analysis that shows improvements over previous work.

Problem Statement:

Many current programs lack localization capabilities, flexible customization choices, and sufficient support for regional languages like Pashto and Urdu, even though AAC tools are readily available. This restricts their efficacy and inclusion for kids in environments with many languages and cultural diversity.

Objectives:

Using the Flutter framework to create a cross-platform AAC mobile application that supports multilingual communication and adaptable symbol libraries. The suggested solution's advantages in terms of usability and local language support will be demonstrated through practical validation in the form of field testing in educational settings and a comparison with other AAC systems.

Related Work:

This section is divided into three categories: Symbol-based communication apps, Text-to-speech communication apps, and Comprehensive AAC apps.

Symbol-Based Communication Apps:

Spoken:

Spoken AAC is an assistive technology that helps people with communication difficulties communicate using visual symbols and text-to-speech functionality. The app can be personalized to the user's needs and supports multiple languages. Spoken AAC generally enhances communication abilities for users with disabilities [1].

Cboard:

Cboard is a user-friendly online AAC tool that facilitates communication using symbols and text-to-speech functionality. This ad-free application is regularly updated to improve its usability, making it a suitable option for a diverse range of users [2].

LetMeTalk:

A free AAC application featuring a vast library of visual aids and sentence construction tools. It accommodates multiple languages and provides audio playback of user-generated messages. LetMeTalk is a highly adaptable solution that promotes self-reliance and social engagement [3].

Text-To-Speech Communication Apps:

Say It!:

A straightforward iOS application that utilizes text-to-speech functionality, designed to assist individuals with communication difficulties, such as those with autism or cerebral palsy. The app provides features like phrase recall and word prediction, though it lacks the ability to convey tone and emotion [4].

Proloquo2Go:

This customizable application integrates visual symbols and text-to-speech capabilities to assist individuals who are nonverbal in expressing themselves. Its flexibility and lifelike voice output facilitate engaging dialogues [5].

Quick Talk:

An AAC tool with customizable features that is category-based. It provides a solution that is accessible to nonverbal people by supporting both text-to-speech and recorded voice [6].

Comprehensive AAC Apps:

TouchChat:

An iOS app offering symbols and predictive text for nonverbal communication. Future updates could focus on expanding the symbol collection and improving customization [7].

Avaz:

An image-based communication program that supports text-to-speech and is accessible in many languages, including Indian and English. For those who have trouble speaking, it is very customizable [8].

LAMP Words for Life:

This structured AAC application provides a pre-designed vocabulary system intended to improve communication and language development for individuals with communication impairments [9].

Communication Apps for Specific Populations:

Tippy Talk:

Crafted for individuals with autism who have difficulty communicating verbally, this application employs picture-based messages to facilitate interaction with caregivers [10].

Buzz Cards:

A digital tool that employs flashcards to assist deaf individuals in communicating with those who are unfamiliar with sign language [11].

Academic or Research Literature:

Telling Tales: Unlocking the Potential of AAC Technologies This paper examines the historical development and obstacles surrounding AAC technologies. A key focus is the low rates of adoption and high abandonment levels for these technologies [12]. The paper

underscores the critical importance of user-centered design approaches and the provision of continuous support for individuals using AAC systems.

Comprehensive AAC Apps:

Tobii Sono Flex:

This application uses text-to-speech and symbols to facilitate communication for those with speech impairments. Touch interaction and eye-tracking technologies are among the several input techniques it offers [13].

Leeloo AAC

Based on the ideas of AAC and PECS, this communication software was created for kids with autism. Because it can be customized and has text-to-speech capabilities, it may be used by both adults and children who struggle with communication [14].

Symbol And Text-Based AAC Apps:

CoughDrop:

CoughDrop is a communication tool that helps people with speech difficulties by using text and symbols. With its multilingual support and cross-platform compatibility, it provides a flexible option for a wide range of users [15].

Jellow Communicator:

Jellow is an AAC app that utilizes symbols and is designed for children with speech and language difficulties. Its straightforward interface, crafted with low-literacy users in mind, prioritizes inclusivity. Furthermore, the app offers language support for various regional dialects, which aligns with its existing capabilities for Urdu and Pashto [16].

Communico:

Communico is an easy-to-use AAC program that uses pictures and symbols to aid kids who have trouble speaking. Young users or those with weak reading skills will find it perfect because of its customizable design and pre-defined symbol library [17].

TalkTablet:

TalkTablet is an app that helps those who have trouble speaking by providing text-to-speech and customizable communication boards with visual symbols. It is a useful tool for kids with developmental disorders like autism since it is highly customizable [18].

Snap + Core First:

Snap + Core First is an AAC software that focuses on symbol-based communication and basic vocabulary for those with complex needs. With the ability to create personalized message boards with text and symbols, it supports a large number of languages and dialects and users of all ages [19].

Table 1. Comparison of AAC Applications, Devices, and Features

Spoken	Android, iPhone	Symbol-based	Retrofit, OkHttp, Glide, Firebase	Yes	Multiple	Limited
Cboard	Web application	Symbol-based	Customizable	No	Not specified	Extensive
LetMeTalk	Android, iPhone	Symbol-based	Extensive image database	No	Multiple	Limited
SayIt!	iOS	Text-to-speech	N/A	No	Not specified	Not specified
Proloquo2Go	iOS	Text-to-speech	Customizable	No	Multiple	Extensive
Quick Talk	iOS	Text-to-speech	Category-based with extensive library	No	Multiple	Limited
TouchChat	iOS	Comprehensive AAC	Vast symbol library	Yes	Multiple	Extensive
CoughDrop	Android, iPhone	Symbol-based	Customizable communication boards, cloud sync	Yes	Multiple	Extensive
Jellow Communicator	Android, iPhone	Symbol-based	Customizable	No	Multiple	Extensive
Communico	Android, iPhone	Symbol-based	Customizable	No	Multiple	Extensive
TalkTablet	Android, iPhone	Symbol-based, Text-to-speech	Customizable, cloud sync	Yes	Multiple	Extensive
Snap + Core First	iOS	Symbol-based	Integration with high-tech devices	Yes	Multiple	Extensive
App	Devices	Communication Method	Libraries Used	Real-time Capabilities	Language Support	Customization Options
Spoken	Android, iPhone	Symbol-based	Retrofit, OkHttp, Glide, Firebase	Yes	Multiple	Limited
Cboard	Web application	Symbol-based	Customizable	No	Not specified	Extensive
LetMeTalk	Android, iPhone	Symbol-based	Extensive image database	No	Multiple	Limited
SayIt!	iOS	Text-to-speech	N/A	No	Not specified	Not specified
Proloquo2Go	iOS	Text-to-speech	Customizable	No	Multiple	Extensive

Quick Talk	iOS	Text-to-speech	Category-based with extensive library	No	Multiple	Limited
TouchChat	iOS	Comprehensive AAC	Vast symbol library	Yes	Multiple	Extensive

Methodology:

This section presents the architecture of an application designed to assist children who are deaf or hard of hearing. The application serves as an AAC tool, developed using Visual Studio Code in combination with the Flutter framework. We utilized Visual Studio Code — a versatile and lightweight code editor that facilitates efficient Flutter development — along with Flutter, an open-source UI framework known for its cross-platform features, to create the AAC application.

Flutter Framework:

Flutter was selected for this project due to its ability to develop cross-platform mobile applications that offer a reliable, intuitive, and engaging user experience for children with speech difficulties. Its robust widget-based system and smooth performance made it ideal for creating an accessible communication tool.

Flutter Packages:

The application was developed in Flutter 3.2.0, leveraging the following packages for core functionality:

- **Flutter_tts** (v5.1.0) for text-to-speech synthesis
- **Speech_to_text** (v5.2.0) for voice input
- **Provider** (v6.0.0) for state management
- **Shared_Preferences** (v2.0.15) for local persistence. These packages were selected for their stability and active community support.

Visual Studio Code:

The AAC application was written, debugged, and tested within an integrated environment using Visual Studio Code. Its features — including powerful debugging tools, intelligent code completion, and integrated terminal support — streamlined the development process and contributed to the rapid iteration of app features.

Features:

Symbol-Based Communication:

The application allows children to express themselves by selecting symbols that represent words, phrases, or emotions, thereby facilitating more effective communication.

Text-to-Speech Functionality:

A built-in text-to-speech feature converts selected symbols into spoken words, enhancing communication across different languages and supporting verbal expression.

Customizable Symbols:

Users have the ability to add and modify symbols according to their individual needs, allowing for a personalized communication experience tailored to each child's unique preferences.

Voice Output Options:

The app offers pre-recorded voice options, providing a more personalized and comfortable communication experience for users.

Emotional Expression:

The emotional expression feature allows children to convey their feelings more deeply, supporting social and emotional development through symbol selection.

Customizable Language Support:

The application includes customizable language settings, enabling users to choose their preferred languages and dialects to enhance accessibility and inclusivity.

User Interface Design:

The user interface is designed to be colorful, intuitive, and highly accessible, featuring large, easily tappable icons to ensure ease of use for young children and individuals with limited motor skills.

Testing and Improvement:

An iterative testing and refinement process was employed to ensure that the application meets high standards of functionality, usability, and accessibility. Continuous feedback from trial users was incorporated into the development to enhance user satisfaction and effectiveness.

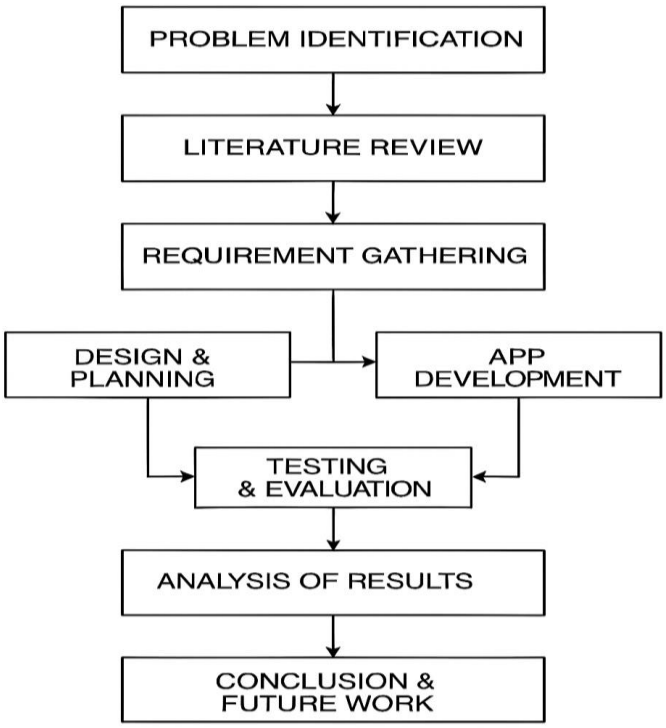

Figure 1. Methodology Flow Diagram

Results:

This chapter presents the trial results of the AAC application developed to support children with speech impairments in communicating effectively.

System Architecture

Development began with the design of robust system architecture. The application was built using the Flutter framework and Visual Studio Code to ensure flexibility and compatibility across multiple devices. Figure 4.1 illustrates the system architecture, highlighting the integration of key components that facilitate symbol-based communication.

Table 2. Specifications

S.No	Name	Description
1	Symbol Library	Repository of symbols and images for communication
2	Text-to-Speech Engine	Converts selected symbols into spoken words
3	Voice Output Support	Integration of pre-recorded voices for symbols and sentences

Figure 2. System Architecture

User Interface Design:

The design of the user interface (UI) plays a critical role in ensuring accessibility for children with speech impairments. Our primary objective was to develop a visually appealing and highly intuitive interface, featuring bold and colorful icons that are large and easy to interact with. These design choices aim to minimize cognitive load and maximize ease of use, supporting independent communication. Figure 3 presents the graphical user interface of the AAC application, highlighting the key user-friendly design elements that enhance accessibility and engagement.

Figure 3. GUI of AAC Application for English

Figure 4. GUI of AAC Application for Urdu

Figure 5. GUI of AAC Application for Pashto

Symbol-Based Communication:

The AAC application's fundamental capability is symbol-based communication, which allows users to smoothly select symbols or images representing words, sentences, or emotions to successfully transmit their messages.

Voice Output:

The application provides voice output in addition to text-to-speech, allowing users to employ pre-recorded voices for symbols and longer words.

Evaluation:

We assessed our AAC application's effectiveness and user satisfaction in order to determine how well the app facilitates communication, we had to interact directly with children who have speech impairments and watch how they use it. In order to learn about user experiences, difficulties, and potential areas for development, qualitative input was also gathered via surveys and interviews. We visited schools with speech-impaired students enrolled to perform field assessments. This allowed us to utilize the app hands-on and obtain firsthand input on its impact, usability, and functioning. Additionally, we conducted a thorough comparison of our AAC program with other top options, emphasizing important

characteristics, compatible devices, modes of communication, and libraries used in the applications.

Figure 6. Conduction of Physical Evaluation for AAC App

User Satisfaction:

The major metric of success was end-user satisfaction. Children's reactions to the AAC application were largely favorable. Positive reception was indicated by visual signs such as smiles and greater involvement. The application's design, which included bold, colorful icons and an easy-to-use interface, contributed to the satisfaction of both users and caregivers.

Real-world Usage:

The real-world usage situation in educational settings provided us with useful information about the application's performance. The symbol-based communication, text-to-speech, and customizable symbols features were extremely valuable to children across all grades. The application's ability to handle various languages—English, Urdu, and Pashto—was particularly praised, as it increased its adaptability to a wide range of linguistic backgrounds.

Visual Feedback:

The addition of visual input, such as photographs of the children's interactions, enhanced our evaluation process. The captured moments demonstrated the children's genuine excitement and happiness while utilizing the AAC program. These visualizations provide real evidence of the app's positive influence and acceptability among the user community.

Incorporating Feedback for Refinement:

During the assessment phase, feedback from both users and instructors was crucial for refining and improving the AAC application. Based on observed user behaviors, suggestions for enhancing specific features or adding new functions will be considered in future updates, ensuring a continuous improvement cycle.

Comparison of Augmentative and Alternative Communication (AAC) Applications:

The AAC application's main features were thoroughly compared with those of well-known alternatives, such as Spoken, Cboard, LetMeTalk, SayIt!, Proloquo2Go, Quick Talk, and TouchChat. Through this comparison, we ensured that our program includes all necessary features and effectively meets the unique communication requirements of children with speech disabilities.

Table 3. Comparative Analysis

App	User Satisfaction	Real-world Usage	Visual Feedback	Incorporating Feedback	Overall Performance
Spoken	Positive	Valuable	Not specified	Considered in future	Effective
Cboard	Positive	Highly valuable	Not specified	Continuous improvements	Effective
LetMeTalk	Positive	Empowering	Not specified	Collaboration for refinement	Powerful
SayIt!	Favorable	Enhances social interaction	Not specified	Continuous improvement	Valuable
Proloquo2Go	Empowering	Enables effective communication	Not specified	Ongoing development	Powerful
Quick Talk	Empowering	Convenient and efficient communication	Not specified	Ongoing updates and collaboration	Valuable
TouchChat	Versatile options	Versatile communication options	Not specified	Future developments	Feature-rich
Avaz	Efficient usage	Personalizable	Not specified	Used effectively worldwide	Beneficial
LAMP Words for Life	Supportive	Simplifies learning	Not specified	Future developments	Effective
Tippy Talk	Facilitates communication	Enhances communication between non-verbal individuals and caregivers	Not specified	Potential for further development	Practical Solution
BuzzCards	Provides practical solution	Smooth and efficient communication	Not specified	Potential for further development	Promotes inclusivity

Summary, Conclusion, and Future Work:

Summary:

This project showcases a robust AAC application designed to assist children with speech impairments, utilizing Flutter and Visual Studio Code. Customizable symbols, text-to-speech, audio output, and symbol-based communication are important features. Flutter's adoption ensures cross-platform compatibility, and the user-friendly interface's bold, colorful icons increase user engagement and usability.

Conclusion:

For children with communication difficulties, we created an Augmentative and Alternative Communication (AAC) application that is accessible, flexible, and easy to use. The software offers a complete communication solution with configurable symbols, text-to-speech, audio output, and symbol-based conversation. In addition to addressing fundamental communication issues, it fosters an environment that supports productive self-expression. With its sophisticated functionality, smart design, and adaptability, the software makes a substantial contribution to assistive technology and enhances the lives of its users.

Future Work:

In the future, there are a number of ways to increase the efficacy of the AAC application. Improved feature extraction and classification techniques to increase the accuracy of symbol transmission, real-time dynamic replies depending on user input, and more expressiveness possibilities are possible future advances. Including collaborative tools to facilitate communication between caregivers and users may provide a more encouraging atmosphere. Maintaining improvements in usability and efficacy for the intended consumers will need constant study and development.

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