A MOBILE APPLICATION TO IMPROVE ONLINE LEARNABILITY TO VISUALLY IMPAIRED ELEMENTARY SCHOOL CHILDREN

Project Id: TMP-23-310

Project Final Report Group

BSc (Hons) in Information Technology Specializing in Information Technology

Department of Information Technology

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Declaration of the Candidate and the Supervisor

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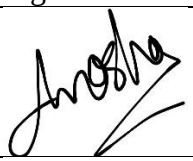
Sathsarani B.A.D.A	IT20160098	
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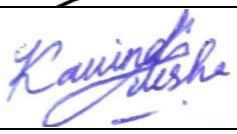
Nayanananda W.A.K.D	IT20237622	

The above candidates are carrying out research for the undergraduate Dissertation under my supervision.

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Abstract

In an era marked by the transformative potential of technology, our research endeavors to enhance the online learning experience for visually impaired elementary school children. This comprehensive research report presents a multifaceted approach to achieving this objective, with a focus on five interconnected sub-objectives. The first sub-objective introduces a supportive voice bot capable of facilitating learning in multiple languages, ensuring accessibility and usability for diverse linguistic populations. The second sub-objective delves into the development of an e-learning platform where visually impaired learners can receive tutoring support, fostering an inclusive and personalized educational environment. The third sub-objective assesses the effectiveness of learning activities conducted through the platform, providing empirical insights into the impact of our solutions. The fourth sub-objective involves the creation of a tutor recommendation system, tailoring educational resources based on learner knowledge and disability levels. Lastly, the fifth sub-objective aims to enhance the accessibility mode within the system, further improving the visual experience for users. The methodology behind these sub-objectives is meticulously detailed, including the steps involved in constructing a multilingual voice bot, the technical aspects of a voice-based calculator, the development of educational games, and the implementation of accessibility features. The research process utilizes natural language processing techniques, voice recognition, and database management to create an integrated e-learning ecosystem. Our research culminates in an inclusive and effective e-learning solution, where visually impaired primary school students can engage with educational content seamlessly. The results demonstrate the successful achievement of each sub-objective, providing a holistic approach to improving the educational experience of visually impaired students. This research report contributes not only to the advancement of accessible online education but also to the broader conversation on leveraging technology for inclusive learning environments.

Keywords— Visually impaired education, E-learning, Tutor recommendation, Voice-based calculator, Gaming module, Supportive voice bot, Accessibility, Primary students, Natural Language Processing

Acknowledgement

We would like to extend our collective appreciation to all who contributed to the successful conclusion of this study. Without the guidance, support, and assistance of each team member, this accomplishment would not have been possible. Our foremost thanks go to our supervisors, Ms. Chathurangika Kahandawaarachchi and Mr. Sathira Nimesh Hettiarachchi, whose expertise, ideas, and unwavering support have significantly shaped the quality and direction of this work. Their patience, encouragement, and constant guidance were pivotal in our journey. We also want to express our gratitude to our mentors, colleagues, peers, friends, and family, as well as the wider academic and research community, whose contributions and encouragement enriched this study. Together, we celebrate the collective effort that made this achievement possible.

We are also grateful to the academic staff and research researchers who gave useful feedback, ideas, and recommendations during the project. Their helpful critique and intellectual contributions significantly improved the research's quality and rigor. and we want to thank our family and friends for their constant support, understanding, and motivation during this journey. Their love, support, and faith in our skills have been a continual source of strength and inspiration.

Finally, we want to convey our heartfelt gratitude to everyone who has contributed to any capacity, be it substantial or modest, to bring this study to fruition. Your contributions have been invaluable, and we are deeply appreciative of the privilege to collaborate with such remarkable individuals.

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List Of Abbreviations

NLP - Natural Language Processing

TTS - Text-to-Speech

STT - Speech-to-Text

API - Application Programming Interface

GUI - Graphical User Interface

SQL - Structured Query Language

UI - User Interface

JSON - JavaScript Object Notation

HTTPS - Hypertext Transfer Protocol Secure

DNS - Domain Name System

URL - Uniform Resource Locator

HTTPS - Hypertext Transfer Protocol Secure

API - Application Programming Interface

1. Introduction

In the pursuit of inclusive and equitable education, technological advancements continue to play a pivotal role in addressing the unique challenges faced by visually impaired primary students. The proposed e-learning system represents a pioneering solution designed to empower visually impaired pupils with a comprehensive educational experience. Comprising four essential components, this system leverages cutting-edge technology, utilizing React Native as its core framework and MongoDB as its database. Let's explore how each of these components works together to create a transformative learning environment:

1. Tutor Recommendation System: The foundation of this system lies in its ability to recommend suitable tutors based on students' online test scores and any specific impairments they may have. By tailoring the tutor-student pairing to individual needs, this functionality ensures that students receive personalized support, enhancing their educational journey with higher satisfaction.

2. Voice-Based Calculator: The integration of a simple voice-based calculator assists students in effortlessly performing elementary arithmetic operations, promoting independent and accessible learning.

3. Voice-Based Gaming Module: Learning should be engaging and enjoyable for all students, including visually impaired individuals. The inclusion of a voice-based gaming module injects fun into the learning process, fostering a dynamic educational environment that enhances students' knowledge while making studying an exciting experience.

4. Supportive Multilingual Voice Bot: Language should never be a barrier to learning. The system's supportive voice bot, capable of communicating in Sinhala, English, and Tamil, ensures that students can interact with the program in their preferred language. This not only facilitates better understanding but also creates an inclusive space for diverse linguistic backgrounds.

Collectively, this comprehensive e-learning system not only improves the knowledge base and skills of visually impaired primary students but also simplifies their daily study routines. By reducing barriers to access and ensuring a personalized and engaging learning experience, this system contributes significantly to social equality in education.

In conclusion, the suggested e-learning system for visually impaired primary students embodies innovation, inclusivity, and empowerment. By harnessing technology to cater to the unique needs of visually impaired students, it paves the way for a brighter and more equitable future in education.

1.1 Background Literature

The rapid advancement of technology has ushered in new opportunities in education, particularly within e-learning platforms. Ensuring that these platforms are comprehensive and accessible to all learners, including those with visual disabilities, is imperative. Visually impaired students require unique methods to enhance their educational experiences.

Numerous researchers have dedicated their efforts to understanding the needs of visually impaired students in the context of digital platforms for online learning. Current studies have investigated how these students engage with digital platforms, the challenges they face, and the types of digital platforms best suited to their needs [1].

To enhance the online classroom experience for visually impaired students, several approaches have emerged. One approach involves the integration of learning technology with pedagogy, students, facilitators, and the creation of an inclusive learning environment [2]. Another framework focuses on the integration of innovative learning techniques with instruction, students, facilitators, and the establishment of a comprehensive learning environment [3].

This review aims to examine current research on e-learning programs specifically designed for visually impaired pupils. We seek insights into the design elements and features that can enhance the usability and efficiency of such platforms. Four main topics are the focus of our exploration: Supportive voice bots, simple voice-based calculators, voice-based gaming modules, and tutor recommendation modules based on knowledge levels and disabilities.

Advancements in technology have played a pivotal role in creating inclusive learning environments. IBM's pioneering work in digital voice recognition technology in the 1990s marked the initial step towards transformative innovations. Subsequently, Apple's Siri, Google's "Google Now," Microsoft's "Cortana," and Amazon's "Amazon Alexa" have led to the era of voice-driven experiences [4].

Recent research [5] has demonstrated the capability to translate speech into various accents, such as Japanese. This sophisticated text-to-speech model uses the power of BERT to ensure accurate pronunciation and even adapts the tone based on the emotions expressed in the input text. Such advancements mark significant achievements in text-to-speech technology [6].

Daily tools like calculators have also seen improvements. Smartphone calculator apps now offer voice commands, making calculations accessible to those who are unable to see or use traditional calculators. Innovations like the Voice Input Speech Output (VISO) Calculator's Bangla Speech Recognition have been implemented to address this need [7].

Educational tools tailored to visually impaired individuals have garnered attention. The Edu Braille calculator, introduced in 2019, can display Braille codes, although it lacks sound features. Further enhancements are needed to make it more effective, such as sound cues and additional displays on Android smartphones [8]. Additionally, a voice calculator with Braille capabilities has been developed, albeit with room for self-correction improvements [9].

Studies like "Design and implementation of an educational game considering issues for visually impaired people inclusion" [10] and “Design, implementation, and evaluation of a mobile game for blind people: toward making mobile fun accessible to everyone” [11] have focused on creating

engaging educational games with audio-based components. Meanwhile, "Egg Pair–A Hearing Game for the Visually Impaired People Using RFID" [12] explores RFID-based games.

Innovations extend to online examinations, with "Voice-based Online Examination System for Visually Impaired Students" proposing a voice-command-driven assessment approach [13]. Another system under "Online Examination System for Visually Challenged" has been designed to provide a more accessible testing method for visually impaired pupils, incorporating voice commands and speech-to-text conversion [14].

An Android app named "FindMyTutor: A Private Tutor Matching Service" has been developed, where students can select tutors based on their grades in online tests. This approach aligns with our categorization of visually impaired pupils according to their grade level and disability [15].

While these studies provide valuable insights, synthesizing these technologies is crucial. A longitudinal study should be conducted, focusing on the integration of access technologies, e-learning facilitation tools, and assessment mechanisms. This study will evaluate the sustained impact of these technologies on the educational journey of visually impaired students over time.

1.2 Research Gap

As discussed above, many current research and systems have been presented but it is still not possible to present a complete system with all the proposed features. But this proposed system is more effective and comprehensive.
This table show a summery comparison feature of the proposed system and existing system approach.

Table 1 Research Gap

Features	R1	R2 [6]	R3 [7]	R4 [11]	R5 [15]
Speech-based tutor suggestion module	✓	✗	✗	✗	✗
Speech-based gaming module	✓	✗	✗	✗	✗
Accessibility modes in UI design	✓	✓	✓	✗	✓
Voice input and response capabilities	✓	✓	✓	✓	✓
Supportive voice bot for multilingual languages	✓	✗	✗	✗	✗
Voice-based calculator	✓	✗	✗	✗	✗

When compared to current methods, the research gap found in your new e-learning system is quite significant, and it makes a special contribution to the field of accessible education for primary pupils who are blind or visually impaired. First off, our system fulfills a critical need that is highlighted by the lack of specific speech-based tutor recommendation and game modules in existing systems. The incorporation of these two functions is a fresh element that might significantly improve the engagement and learning outcomes for visually impaired students, even though prior systems may have included a variety of features.

Additionally, our system adopts a novel strategy in UI design accessibility modes by including elements like a speech-based calculator and a helpful voice bot for multiple languages. Our system is more comprehensive and adaptable because of these enhancements, which were not included in earlier study or systems. By allowing students to communicate with the system in their native tongue, the helpful voice bot successfully eliminates language barriers. The voice-based calculator

also makes basic arithmetic operations simpler, improving the system's overall usefulness for visually challenged students.

When it comes to speech input and response capabilities, while other existing studies may have them, our system outperforms them by incorporating a full range of functionality, such as a supportive voice bot and voice-based calculator. This is a step in the right direction toward giving visually impaired primary pupils a comprehensive and user-friendly learning experience that satisfies their unique requirements and obstacles.

2. Research Problem

The current study problem is the urgent need to ensure primary visually impaired pupils' educational equity so they can benefit from the same educational opportunities as their sighted colleagues. These students' particular educational issues need specialized solutions. The need for qualified tutors for visually impaired students is urgent since their progress might be hampered by a lack of focused support. Additionally, the traditional educational system frequently fails to provide visually impaired students with engaging learning opportunities, which causes them to feel bored and uninterested in their studies.

For students who are blind or visually impaired, language hurdles are a significant obstacle that makes it difficult for them to obtain learning resources in their preferred languages. To ensure that these kids can comprehend and interact with instructional materials successfully, multilingual support is essential. Additionally, the difficulty of mathematical calculations might be a barrier since visually impaired children may find it difficult to do complicated calculations owing to their impairment, requiring creative methods to support their mathematical learning.

In summary, the research topic includes the overarching objective of tackling the numerous obstacles that visually impaired primary pupils must overcome in order to pursue an equal and inclusive education. To eliminate the gap and ensure that visually impaired kids may succeed academically on par with their sighted colleagues, comprehensive solutions to these problems are essential.

3. Research Objectives

3.1 Main Objective

The main objective of this research project is to enhance the online learning experience for visually impaired elementary school children through the development and implementation of a comprehensive educational platform. This platform aims to address the unique learning needs of visually impaired students by:

Creating a Supportive Multilingual Voice Bot: The primary goal is to design and integrate a supportive voice bot that operates in multiple languages, including English, Sinhala, and Tamil. This voice bot will facilitate and personalize the learning experience for visually impaired students, making educational content more accessible and engaging.

Establishing an Inclusive E-Learning Platform: The project aims to develop an inclusive e-learning platform that caters specifically to the needs of visually impaired learners. This platform will provide a conducive environment for students to access educational materials, engage in interactive learning activities, and connect with tutors for personalized learning support.

Assessing the Effectiveness of Gaming Learning Activities: The research project will conduct a thorough evaluation of the gaming-based learning activities offered through the platform. The objective is to determine the impact of these activities on the academic and personal development of visually impaired students, including their knowledge acquisition and engagement levels.

Implementing a Tutor Recommendation System: To further enhance the learning experience, the project will create a sophisticated platform feature that recommends tutors based on individual learner profiles, taking into account their knowledge levels and specific disabilities. This personalized approach aims to provide tailored support to each student, ensuring their unique learning needs are met effectively.

The main objective of this research project is to develop and implement an innovative and inclusive educational platform for visually impaired elementary school children. This platform will utilize technology, including a multilingual voice bot, gaming-based learning activities, and personalized tutor recommendations, to improve the online learnability and overall educational experience of visually impaired students. Through these initiatives, the project seeks to empower visually impaired learners and promote their academic and personal growth.

3.2 Sub Objective

The sub-objectives of this research initiative encompass a range of innovative solutions aimed at enhancing the educational experience for visually impaired primary students. Firstly, a critical sub-objective is the creation of a supportive voice bot capable of facilitating learning in multiple languages. This voice bot addresses the language barrier challenge faced by visually impaired students, ensuring that they can interact with educational content in their preferred language, thereby fostering better comprehension and engagement.

Another sub-objective is the development of a voice-based simple calculator. This calculator serves as an invaluable tool to aid visually impaired students in performing basic arithmetic operations, thereby promoting independence and accessibility in mathematical learning.

The creation of a gaming module is yet another sub-objective that aims to inject excitement and interactivity into the learning process. This module seeks to make learning more enjoyable for visually impaired students, fostering a dynamic educational environment that enhances their knowledge and engagement.

Lastly, the sub-objective of establishing a platform for tutor recommendations based on a student's knowledge and level of disability is crucial. This platform ensures that visually impaired students are paired with tutors who can meet their specific educational needs effectively, thus contributing to a more personalized and satisfying learning experience.

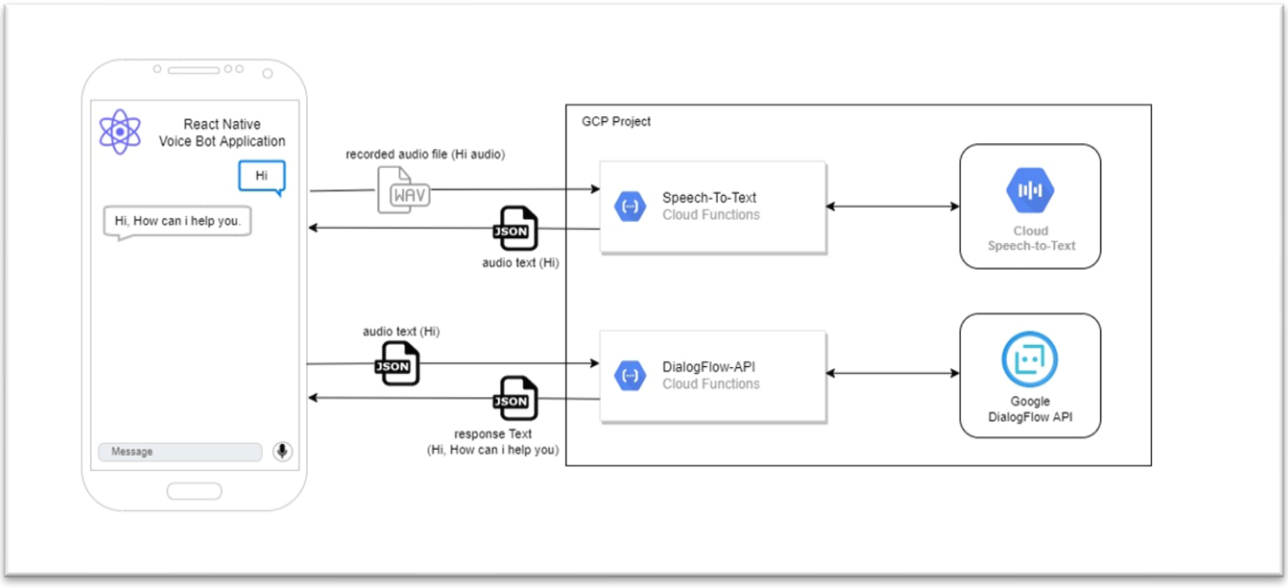
Collectively, these sub-objectives work in harmony to address the diverse challenges faced by visually impaired primary students, ultimately paving the way for a more inclusive and equitable educational landscape.

4. Methodology

The main objective of our application is to enhance the online learning experience for visually impaired elementary school children. This comprehensive solution consists of several interconnected sub-objectives.

- To create a supportive voice bot which facilitates learning in multilingual language.
- To create an e-learning platform for visual impaired learners can meet a tutor for learning support.
- To evaluate the effectiveness of the learning activities conducted through the platform.
- To create a platform to recommend a tutor based on learner's knowledge and level of disability.
- To facilitate the accessibility mode for improving vision in the system.

Supportive voice bot

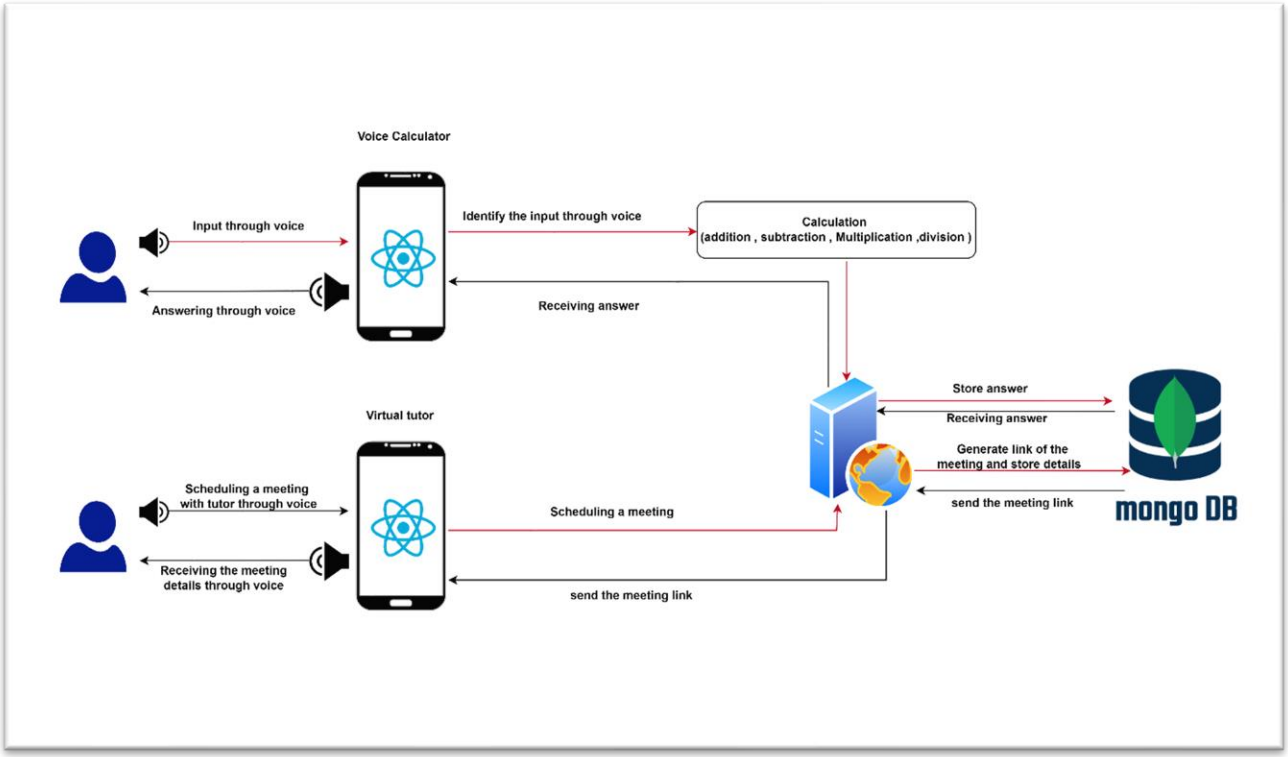


The technique and execution points of interest of developing a multilingual voice bot able of understanding and reacting to client input in three languages: English, Sinhala, and Tamil are presented in this research paper. To form a seamless conversational involvement with clients, the voice bot leverages natural language processing (NLP) procedures such as text-to-speech (TTS), speech-to-text (STT), tokenization, lemmatization, and Wikipedia search. Users can engage with the proposed voice bot by utilizing voice commands in any of the supported languages, allowing for greater accessibility and usability across varied linguistic populations.

Several critical phases are involved in constructing a multilingual speech bot to ensure its operation and efficacy across multiple languages. The procedure starts with data collection and preprocessing.

To train the language detection methods, datasets in English, Sinhala, and Tamil must be obtained. The gathered data is subsequently preprocessed, which entails the elimination of noise, special characters, and extraneous information, preparing the data for later phases. Language detection methods are implemented in Step 2. This entails determining the language of user input using libraries such as 'Langdetect' or other appropriate ways. The recognized language is saved in the processing pipeline for future reference. Step 3 focuses on the development of Language-Specific Functions and Responses. These demands customizing the welcome messages and answers to each supported language. Additionally, unique text-to-speech (TTS) and play audio routines are generated for each language utilizing appropriate TTS libraries. Step 4 addresses tokenization and lemmatization. Each language has its own tokenization and lemmatization functions: English, Sinhala, and Tamil. To effectively preprocess the text, language-specific tokenization, and lemmatization libraries, as well as custom rules, are used. In step 5, a Language-Specific Wikipedia Search feature is added. The generate Response function has been modified to perform language-specific Wikipedia searches based on the language recognized before. Language-specific Wikipedia search libraries or APIs are used to retrieve relevant information from Wikipedia for each language. The procedure concludes with Integration and Testing (step 6). All of the language-specific features created thus far have been smoothly merged into the main voice bot code. Extensive testing follows, encompassing a wide range of user inputs in several languages. This extensive testing step is critical in verifying the voice bot's durability, accuracy, and general efficacy across multiple languages.

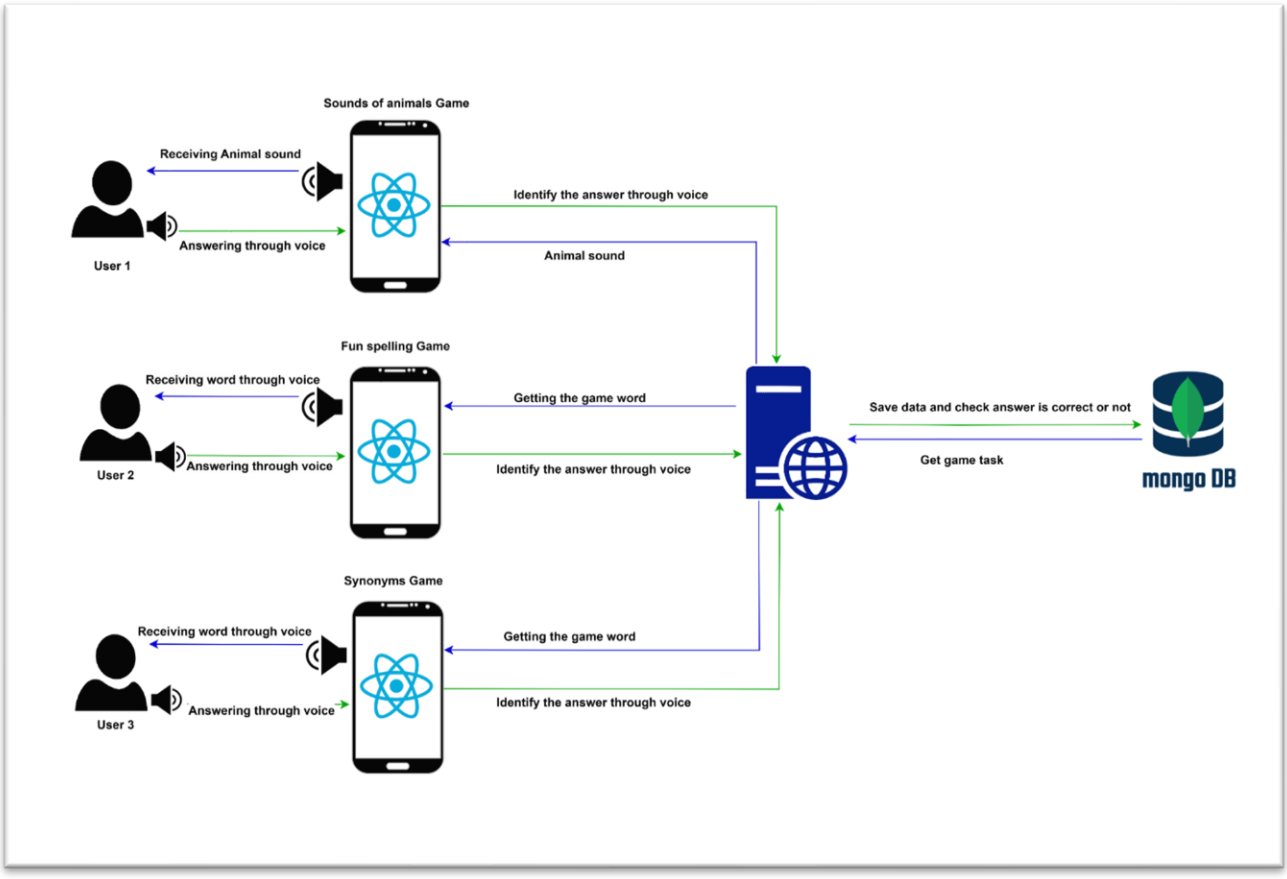
Voice Based Calculator



"Edu Sense," an inclusive and empowering application, is tailored to meet the unique needs of visually impaired students, fostering an environment of accessible and effective learning. At the core of Edu Sense lies the transformative "Voice-Based Calculator" module, seamlessly integrated to provide an exceptional tool for mathematical calculations. This innovative module enables users to effortlessly perform calculations using voice input or touch interactions, ensuring a user-centric experience. Developed as an integral component of Edu Sense, the "Voice-Based Calculator" module is a testament to modern technology's potential to enhance accessibility and inclusivity within education.

The "Voice-Based Calculator" module within Edu Sense extends its capabilities by offering dual modes of interaction: voice and touch. Leveraging the power of the @react-native-voice/voice library, voice inputs are accurately interpreted to execute mathematical operations. By harmonizing a React Native frontend with a Python backend, the module achieves a seamless synergy between technology and user experience. The Python backend, supported by the speech recognition library, captures voice input and employs the eval function to evaluate mathematical expressions. The module not only delivers results through voice outputs but also stores accurate responses in a dedicated database, reaffirming its commitment to functionality and utility. Edu Sense's "Voice-Based Calculator" module exemplifies innovation driven by accessibility, providing visually impaired students with a transformative tool for mathematical exploration and learning.

Gaming module



The Edu Sense application's gaming module is designed for visually impaired users. The module consists of three voice-based games: the Animal Sound Game, the Fun Spelling Game, and the Synonyms Game. The methodology envelops the creation of the games, the information collection prepares, and the assessment of client performance.

The games were created using a combination of programming languages and technologies, including speech recognition computer program, sound handling libraries, and client interface design frameworks. The design of each game involved crafting a user-friendly interface and integrating voice interaction components.

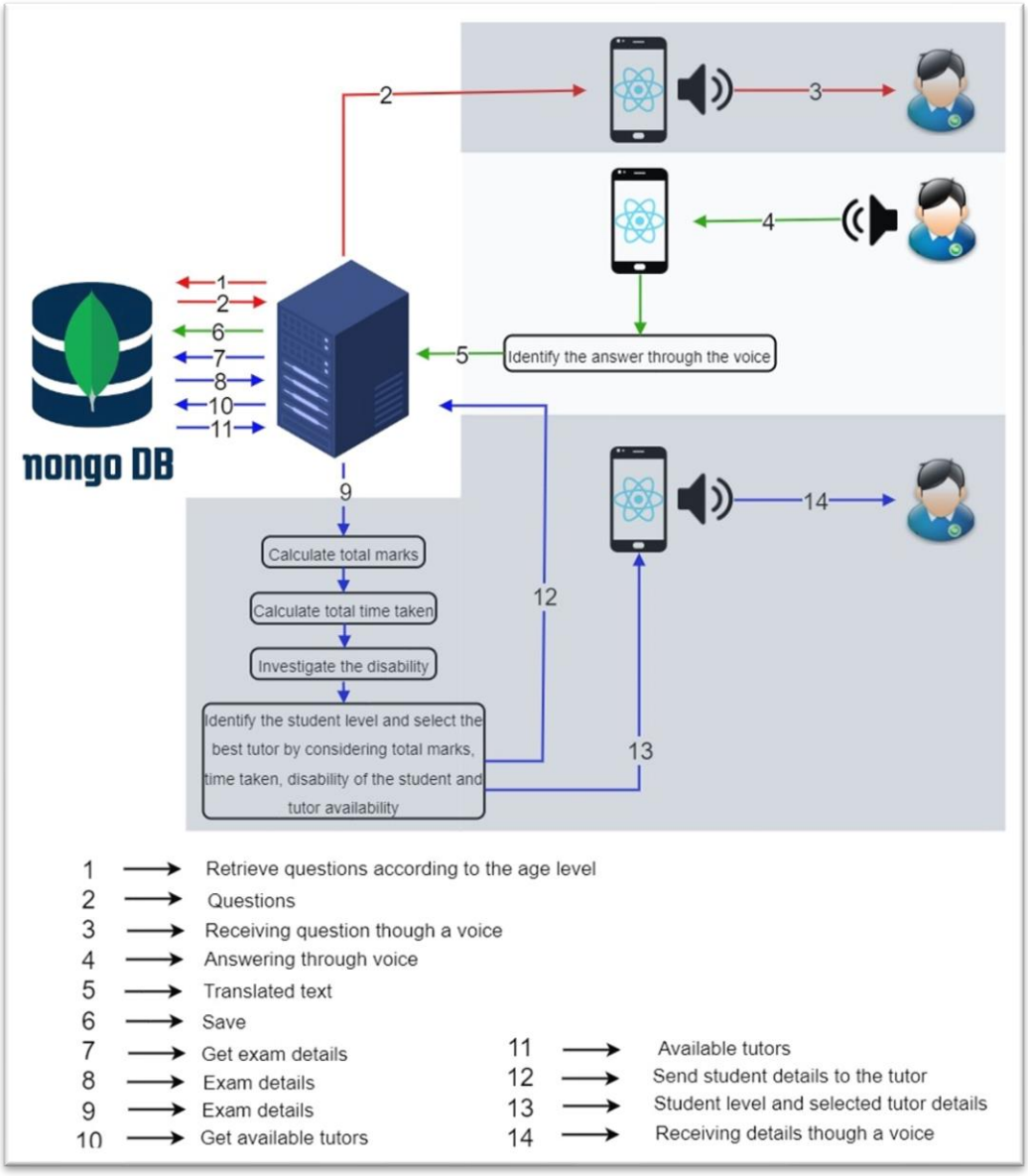
Animal Sound Game: Animal sounds were sourced from reputable audio databases and integrated into the game's framework. The game was programmed to randomly select an animal sound and play it through the device's speaker. Voice recognition software was implemented to capture the user's response, compare it to the correct answer, and provide appropriate feedback.

Fun Spelling Game: A word database was curated for the game, encompassing a diverse range of vocabulary suitable for visually impaired users. The game system was designed to retrieve and play a word through the speaker. Users were prompted to spell the word aloud, and their response was converted to text using speech-to-text technology. The system then compared the user's spelling to the correct spelling, offering feedback accordingly.

Synonyms Game: A database of synonyms was compiled that included the most common words in the language context of the target user. The game presented users with a word played through the speaker. Users were prompted to provide a synonym word using their voice, and the response was converted to text. The system compared the user's synonym word with the correct synonym and provided feedback.

We went ahead and included accessibility features like increasing and decreasing letter sizes, high contrast adjustments, and altering spacing between letters right on the main page. This way, users can easily customize the content to suit their preferences.

Tutor recommendation



The methodology for the recommended e-learning system for visually impaired primary school kids is structured around a cohesive process designed to provide tailored educational resources and specialized online tutoring. The system leverages MongoDB for efficient database management and utilizes React Native for the development of a user-friendly mobile application and a desktop application for administrative tasks. The process begins by obtaining grade-level specific questions from the MongoDB database. The system will conduct an online voice-based examination, featuring a collection of multiple-choice questions for this.

The process commences with the administration module, accessible through the desktop application that has been developed by using React. This module provides authorized administrators with the capability to create new questions, edit existing ones, delete questions, and perform targeted searches by question name. The desktop application's intuitive interface guarantees efficient management and upkeep of the question bank, thus ensuring the relevance and accuracy of the educational content.

These questions are then made accessible to the learners through the React Native app, where voice commands are used to navigate and respond to the online examination. The system's front-end converts the students' spoken answers into text format, which is subsequently stored in the database for analysis.

Upon completion of the online exam, the server retrieves and processes the exam information from the database. This includes evaluating the student's overall performance, time taken, and determination of their knowledge level. The system utilizes a dataset containing information about students' grades, subjects, exam scores, time allocation per question, and knowledge levels, which is then processed using a Machine learning model to assess the students' level of understanding. Based on this assessment, the system recommends the most suitable tutor from a pool of available tutors.

The recommended tutor is then notified with relevant student information, and if the tutor agrees to the assignment, tutoring sessions can commence. The React Native application is employed once again, this time facilitating communication between the student and tutor through voice commands. This streamlined approach ensures that visually impaired students receive not only tailored educational resources but also specialized tutoring, fostering their academic growth and expanding their opportunities.

We've incorporated accessibility features on each page, including options to enlarge or shrink letter sizes, apply high contrast mode, and adjust spacing between letters. This empowers the visually impaired students to customize the content based on their preferences.

Similarly, we have achieved the main objective of our application, enhancing the online learning experience for visually impaired primary school students. As our first sub-objective, we were able to develop a supportive voice bot that operates in multiple languages. Additionally, we had an aim to create an e-learning platform that integrates a user-friendly voice-based calculator for simplified calculations. We have successfully achieved this goal. Our platform also concentrated on engaging learners through educational games, fostering an interest in studies, and incorporating accessibility features to enhance vision. We have succeeded in this sub-objective as well. Finally, we successfully achieved the last sub-objective by providing tailored tutor recommendations based on learners' knowledge levels and disabilities.

Overall, the methodology encompasses a well-defined sequence of steps to offer an inclusive and effective e-learning experience for visually impaired primary school students.

4.1 Overall System diagram

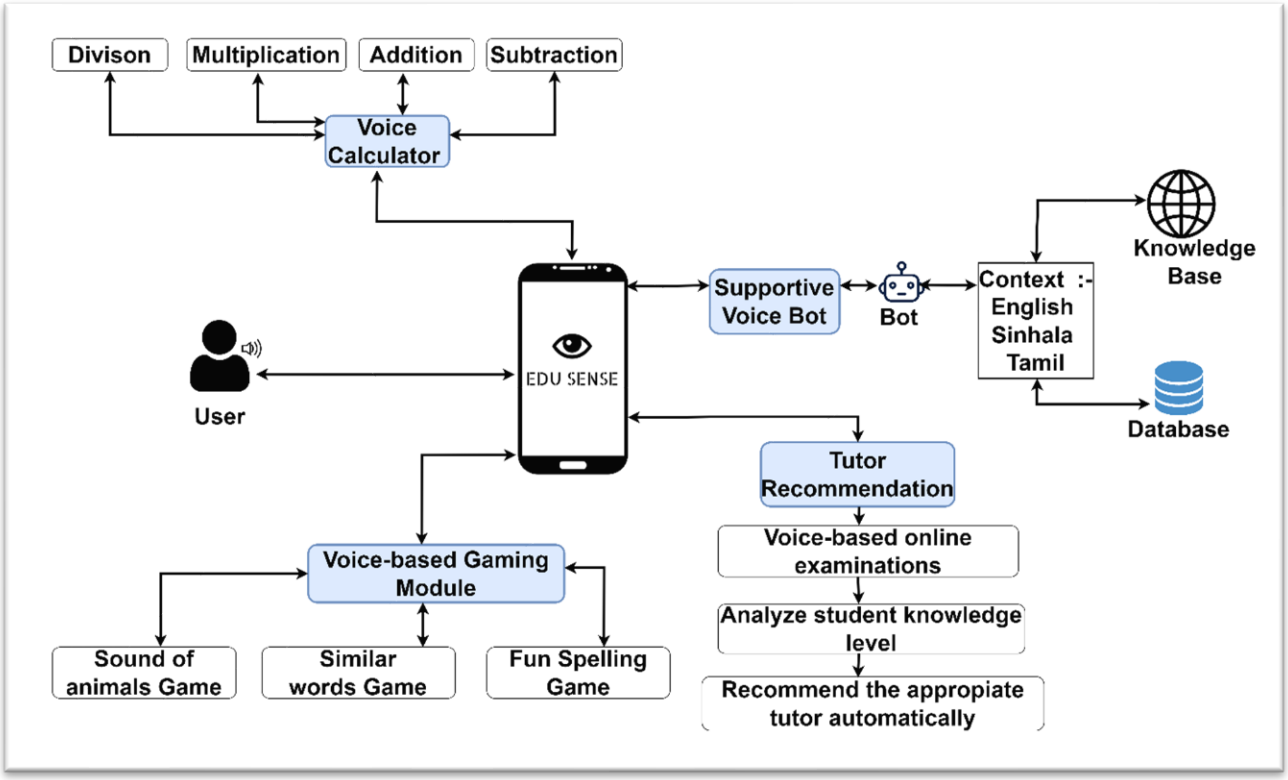


Figure 1 System diagram

4.2 Implementation

Implementing the comprehensive solution to enhance the online learning experience for visually impaired elementary school children involved a meticulous and multifaceted process. The implementation phase translated the research methodology's theoretical framework into tangible, functional components that constitute the Edu Sense application. This implementation report provides an overview of the key steps and technologies employed in turning the research ideas into reality.

The implementation process began with the development of the Supportive Voice Bot, a core component designed to facilitate learning in multiple languages. Leveraging natural language processing (NLP) techniques such as text-to-speech (TTS) and speech-to-text (STT), we set out to create a seamless conversational experience for users in English, Sinhala, and Tamil. The development journey started with data collection and preprocessing. We collected diverse datasets in the three languages, which were subsequently preprocessed to remove noise, special characters, and irrelevant information. Language detection methods, based on libraries like 'Langdetect,' were implemented to identify the user's input language. This language recognition played a crucial role in tailoring responses and interactions. Language-specific functions, responses, and TTS routines were developed for each language, ensuring a culturally relevant experience.

Tokenization and lemmatization were employed to effectively preprocess text inputs in different languages. Custom tokenization and lemmatization libraries and rules were established for English, Sinhala, and Tamil. Furthermore, we integrated a language-specific Wikipedia search feature into the bot to provide contextually relevant information based on user queries. This comprehensive process was brought together in the Integration and Testing phase, where all language-specific features were merged into the main voice bot code. Extensive testing across various languages and user inputs was conducted to validate the bot's durability, accuracy, and overall effectiveness.

The Voice-Based Calculator module within the Edu Sense application represents a pivotal component, offering a transformative tool for users, particularly those with visual impairments, to perform mathematical calculations effortlessly. What sets this module apart is its versatile interaction approach, supporting both voice and touch inputs to cater to a wide range of user preferences and accessibility needs.

At the heart of this module lies a robust technological stack that combines the power of '@react-native-voice/voice' library and React Native. This technology stack enables the module to accurately interpret voice inputs, transforming spoken mathematical expressions into executable operations. The Python backend complements this functionality by seamlessly integrating speech recognition libraries, allowing the system to capture and process voice input effectively.

When a user interacts with the Voice-Based Calculator module using voice input, the system employs the 'eval' function within Python. This function is pivotal in evaluating complex mathematical expressions with precision, ensuring that calculations are performed accurately. The real-time execution of mathematical operations through voice input not only enhances the user

experience but also serves as an educational tool for users to understand and explore mathematical concepts.

Moreover, this module goes beyond providing just voice outputs. It includes a data storage mechanism that securely stores accurate responses in a dedicated database. This feature serves a dual purpose – firstly, it enables users to review and reference their past calculations, promoting a sense of continuity and learning. Secondly, it assists educators and caregivers in monitoring the progress of users, ensuring that their mathematical skills are improving over time.

The Voice-Based Calculator module, with its dual interaction modes and advanced technological stack, represents a significant advancement in making mathematics more accessible and enjoyable for users with visual impairments. It exemplifies the commitment of Edu Sense to inclusivity and education, providing a tool that empowers users to excel in mathematics while embracing their individuality and preferences.

In the initial phases of planning and designing the Edu Sense application, a user-centered approach is at the core of our development strategy. Our primary focus is on visually impaired users, and we begin with a thorough requirement analysis to understand their unique needs and preferences. By segmenting our user base based on factors like age, educational background, and specific requirements arising from visual impairment, we can tailor our gaming modules effectively.

Accessibility and technical requirements are another vital aspect of our planning. We ensure a seamless user experience by identifying and acquiring the necessary hardware components and specifying the software stack, particularly emphasizing voice recognition technology for natural and voice-based interactions.

The user interface (UI) design is a critical element of our approach, and we follow key principles to make it inclusive and user-friendly. We prioritize simplicity and clarity, incorporate voice-activated navigation, introduce intuitive gestures like the double tap and swipe, and provide clear audio feedback for all user actions. These design principles aim to create a seamless and enjoyable user experience for our visually impaired users.

Moving into the development phase, each game module receives specialized attention. For the Sound of Animals Game, we focus on delivering an authentic audio experience by sourcing high-quality animal sounds, integrating them seamlessly into the system, and implementing voice recognition technology for user responses.

In the Fun Spelling Game, our development efforts concentrate on compiling a diverse list of words, enabling voice input for spelling, and designing a feedback mechanism to promote learning and engagement.

In the Synonyms Game, the goal is to enrich users' vocabulary and language skills by building a robust word and synonym database, implementing voice input and recognition, and providing feedback on synonym accuracy.

Finally, in the testing phase, we ensure the reliability and correctness of our gaming modules through unit testing and integration testing. User testing is a pivotal step, where a diverse group of

visually impaired individuals participates in beta testing, providing valuable feedback on usability, accessibility, and overall satisfaction. This feedback loop allows us to identify and resolve any issues, make necessary enhancements, and ensure that the Edu Sense application truly caters to the needs of its users, making learning accessible and engaging for all.

The implementation for the Tutor Recommendation system was structured around MongoDB for efficient database management and React Native for mobile and desktop applications. The process commenced with the administration module, accessible through the desktop application, allowing administrators to manage questions efficiently. Questions were then made accessible to learners through the React Native app, enabling voice-based navigation and responses during online examinations. The system converted spoken answers to text for storage and analysis.

In our online examination system, students receive their results, and the system predicts their knowledge level to recommend the most suitable tutor. We developed a machine learning model, to evaluate the knowledge level. We evaluated the knowledge level, categorizing it as either advanced, intermediate, or beginner. We utilized data collected from the Blind School in Ratmalana, encompassing variables such as subject, grade, marks, total time duration, number of questions, and knowledge levels, for training this model. Initially, we preprocessed the raw dataset, removing unnecessary columns and converting all data into numerical format using one-hot encoding. After extensive testing, the Random Forest algorithm emerged as the most accurate, achieving an accuracy level of 74.9% after hyperparameter tuning. Subsequently, we created a pickle file using the Random Forest algorithm. Upon inputting relevant data, the model generated an array as output, with the highest value representing the student's knowledge level.

To integrate this machine learning model, we deployed it as an API within our React Native application. Real-time knowledge level predictions are now displayed on the results page, considering factors like exam marks, total exam time, and the number of questions answered. Our system is accessible across the globe because of the server's deployment on the Heroku cloud platform, enabling smooth connections between users with different IP addresses and locations.

The implementation of accessibility features, including text customization options, further ensured the application's usability for visually impaired students. Overall, the implementation of Edu Sense successfully achieved its objectives, offering a comprehensive and inclusive e-learning experience for visually impaired primary school students. Each sub-objective was realized, from the development of the multilingual voice bot to the creation of engaging educational games and the tailored tutor recommendation system. Edu Sense’s commitment to accessibility and inclusivity has been exemplified through its innovative features and functionality. This implementation has the potential to significantly impact the online learning experience for visually impaired students, fostering academic growth and expanding opportunities for this underserved population.

Finally, we integrated the Whole four components including Supportive voice bot, Voice based simple calculator, Gaming module and tutor recommendation module based on the knowledge level and the disability built the Edu Sense e learning mobile application for visually impaired primary students.

5. Software Specifications

5.1 Functional Requirements

The functional requirements for the proposed e-learning system for visually impaired primary students encompass a wide array of features and capabilities aimed at creating an accessible, engaging, and inclusive educational environment.

First and foremost, the system must be capable of user registration and authentication, ensuring secure access to the platform for both students and tutors. User profiles should be customizable, allowing students to input their preferences and accessibility settings.

The core functionality of the system includes a tutor recommendation feature. This feature should assess a student's knowledge level and disability, facilitating the matching of students with suitable tutors. It should also provide a user-friendly interface for students to access tutor profiles and select the most appropriate match.

The system should include a voice-based interactive component, incorporating a supportive voice bot that can communicate in multiple languages. This voice bot should guide students through the learning materials, provide explanations, and answer questions, enhancing the overall learning experience.

To address mathematical learning needs, the system must integrate a voice-based simple calculator. This calculator should be easily accessible within the platform, allowing students to perform basic arithmetic operations with voice commands.

Incorporating a gaming module is another crucial requirement. This module should offer a variety of educational games that are engaging, accessible, and designed to improve students' knowledge and motivation to learn.

Furthermore, the system should support the creation and delivery of educational content in various formats, including text, audio, and Braille. It should provide tools for content creators to ensure accessibility and compatibility with screen readers and other assistive technologies.

The e-learning platform must have a robust database system, such as MongoDB, to efficiently store and manage user data, educational materials, and progress tracking information.

Accessibility features, such as high-contrast interfaces, customizable font sizes, and compatibility with screen readers, are essential to make the platform usable for visually impaired students. Additionally, the system should be responsive and adaptable to various devices, including smartphones, tablets, and computers.

To ensure continuous improvement, the system should collect data on user interactions and progress. This data can be used to refine the recommendation algorithm, assess the effectiveness of educational content, and enhance the overall user experience.

Lastly, the system should have robust security measures in place to protect user data and privacy. This includes encryption of sensitive information, secure data storage practices, and regular security audits to identify and address vulnerabilities.

In summary, the functional requirements of the e-learning system for visually impaired primary students encompass a comprehensive set of features designed to provide an inclusive, engaging, and effective educational experience while prioritizing accessibility, security, and user customization.

5.2 Non -Functional Requirement

The non-functional requirements of the proposed e-learning system for visually impaired primary students define the qualities and characteristics that contribute to the overall performance, usability, and reliability of the platform.

Usability: The system should be highly intuitive and user-friendly, with a clear and accessible user interface. It must be designed to accommodate various levels of technological proficiency among users, ensuring that visually impaired students can navigate the platform with ease.

Accessibility: Accessibility is a paramount non-functional requirement. The system should adhere to international accessibility standards, such as WCAG (Web Content Accessibility Guidelines), to ensure that it can be effectively used by individuals with diverse disabilities. This includes support for screen readers, keyboard navigation, and alternative input methods.

Performance: The system must be responsive and capable of handling a large number of concurrent users without significant lag or downtime. It should have robust performance monitoring and optimization mechanisms in place to maintain a smooth and seamless user experience.

Reliability: Reliability is critical to ensure uninterrupted access to educational resources. The system should have redundant servers and data backup procedures in place to mitigate the risk of data loss or service disruption. Regular maintenance and updates should be conducted to keep the system running smoothly.

Security: Security measures should be rigorous to protect sensitive user data and maintain user privacy. This includes data encryption, secure user authentication, and safeguards against unauthorized access or data breaches. Regular security audits and updates should be part of the system's maintenance routine.

Scalability: The system should be scalable to accommodate future growth and increasing user demands. It should have the flexibility to expand its infrastructure and resources as needed without compromising performance or accessibility.

Interoperability: The system should be compatible with various assistive technologies commonly used by visually impaired students, such as screen readers and Braille displays. It should also be capable of integrating with external systems and databases seamlessly.

Multilingual Support: The system's multilingual capabilities should extend beyond just content translation. It should ensure accurate and culturally sensitive communication in different languages, catering to the diverse needs of visually impaired students from various linguistic backgrounds.

Compliance: The system should comply with relevant regulations and standards governing educational platforms, data protection, and accessibility. This includes adherence to educational content guidelines and data privacy laws.

Feedback and Continuous Improvement: The system should have mechanisms in place to collect user feedback and data on system performance. This information should be used to make continuous improvements to the platform, enhancing its overall usability and effectiveness.

Finally, the non-functional requirements of the e-learning system for visually impaired elementary students are key to ensuring that the platform is not only accessible, but also works reliably, safely, and efficiently in compliance with applicable standards and regulations. These requirements collectively contribute to the success and effectiveness of the system in providing an inclusive and effective educational experience.

5.3 Hardware Requirements

The smooth operation of the Edu Sense application and its gaming modules hinges on specific hardware prerequisites. Users should possess a compatible smartphone or tablet equipped with the following specifications:

- A quad-core processor for optimal performance.
- A minimum of 2GB of RAM to ensure seamless operation.
- Adequate storage space to accommodate both the application itself and game-related data.
- A functional microphone to enable voice interaction.
- While the application can function offline, an internet connection is necessary for initial setup, updates, and access to additional content.
- Compatibility with screen reader software, such as Talkback for Android, is essential to ensure accessibility for visually impaired users.

In addition to these fundamental hardware requirements, users may also consider optional hardware enhancements such as headphones or earphones to enhance the auditory experience. Moreover, accessibility accessories like tactile overlays can further augment the user experience. These hardware prerequisites collectively contribute to the creation of an inclusive and accessible learning environment, particularly benefiting visually impaired individuals who engage with the Edu Sense application.

5.4 Tool and Technology

Tools

I. Visual Studio Code

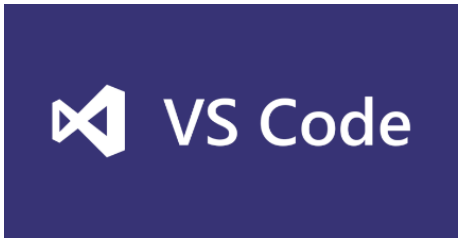


Figure 2 VS Code

Source code editors like Visual Studio Code, sometimes referred to as VS Code, were made by Microsoft. It is free and open source, and it can run on Windows, macOS, and Linux. Additionally, it is designed to be portable, flexible, and cross-platform.

II. PyCharm

Figure 3 PyCharm

PyCharm is an integrated development environment used for programming in Python. It provides code analysis, a graphical debugger, an integrated unit tester, integration with version control systems, and supports web development with Django. PyCharm is developed by the Czech company JetBrains.

III. Jupyter Notebook

Figure 4 Jupyter Notebook

Jupyter Notebook is essential for developing and testing complicated features like voice-based tools and accessibility features since it offers an interactive, collaborative, and adaptable environment. It promotes quick prototyping, supports numerous programming languages, and speeds development, making it a crucial tool for ensuring the system's efficacy for pupils who are blind or visually impaired.

Technology

I. Mongo DB

Figure 5 Mongo DB

Document-oriented database system MongoDB is free and open-source. Documents having JSON-like structure have been used by the NoSQL database application MongoDB. For usage with MongoDB, creator MongoDB Inc. provides the Server-Side Public License.

II.React Native

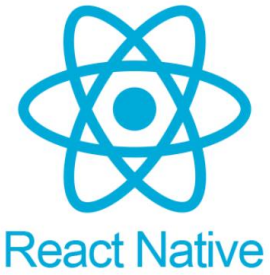


Figure 6 React Native

The popular open source React Native framework was created by Facebook and is used to create mobile applications. From a single codebase, programmers can produce cross-platform mobile applications for the web, iOS, and Android. The web application development library ReactJS serves as the foundation for React Native.

III. Python

Figure 7 Python

Python is a general-purpose, interpreted programming language. Python was developed by Guido van Rossum and originally made available in 1991. Its design philosophy places a strong emphasis on code readability and makes remarkable use of substantial whitespace.

6. Development

6.1 Development of Edu Sense Application

The development of the Edu Sense Android mobile application, along with its integrated Supportive Voice Bot, Voice-Based Calculator, Game Modules, and Tutor Recommendation features, was a meticulous and purpose-driven endeavor designed to improve educational accessibility for visual impairments primary students. Our central objective throughout the app's creation was to prioritize user-friendliness, ensuring a smooth and accessible interface.

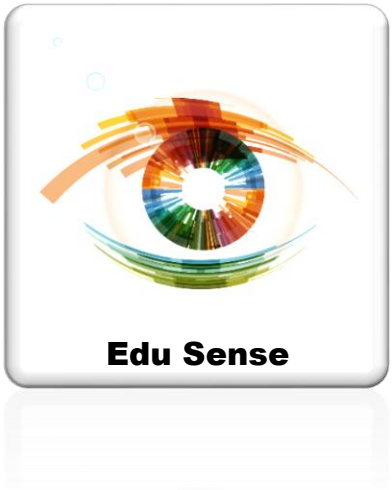


Figure 8 Edu Sense app logo

6.2 Supportive Voice Bot interface (UI)

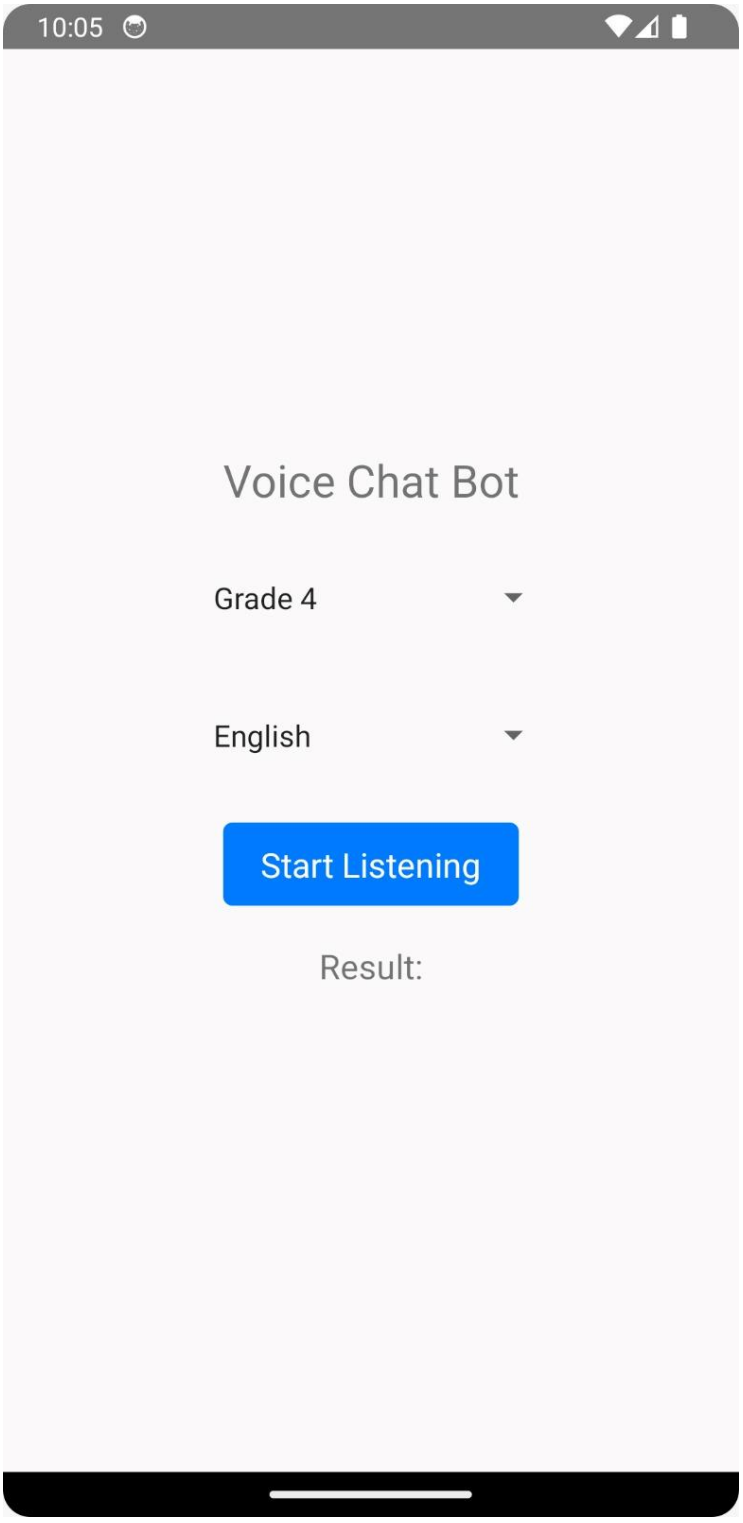


Figure 9 Supportive Voice Bot Home

6.3 Voice based simple calculator interface (UI)

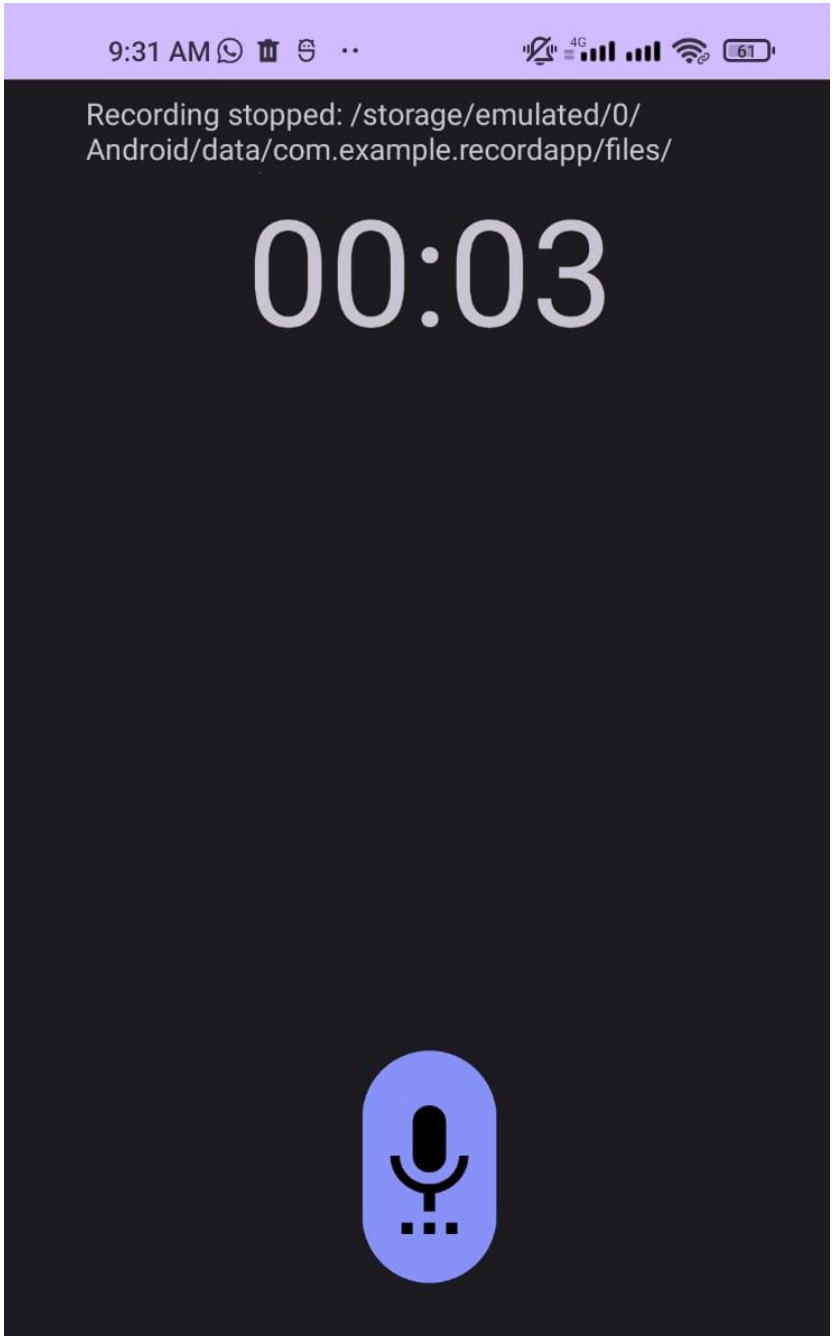


Figure 10 Voice based simple calculator Home.

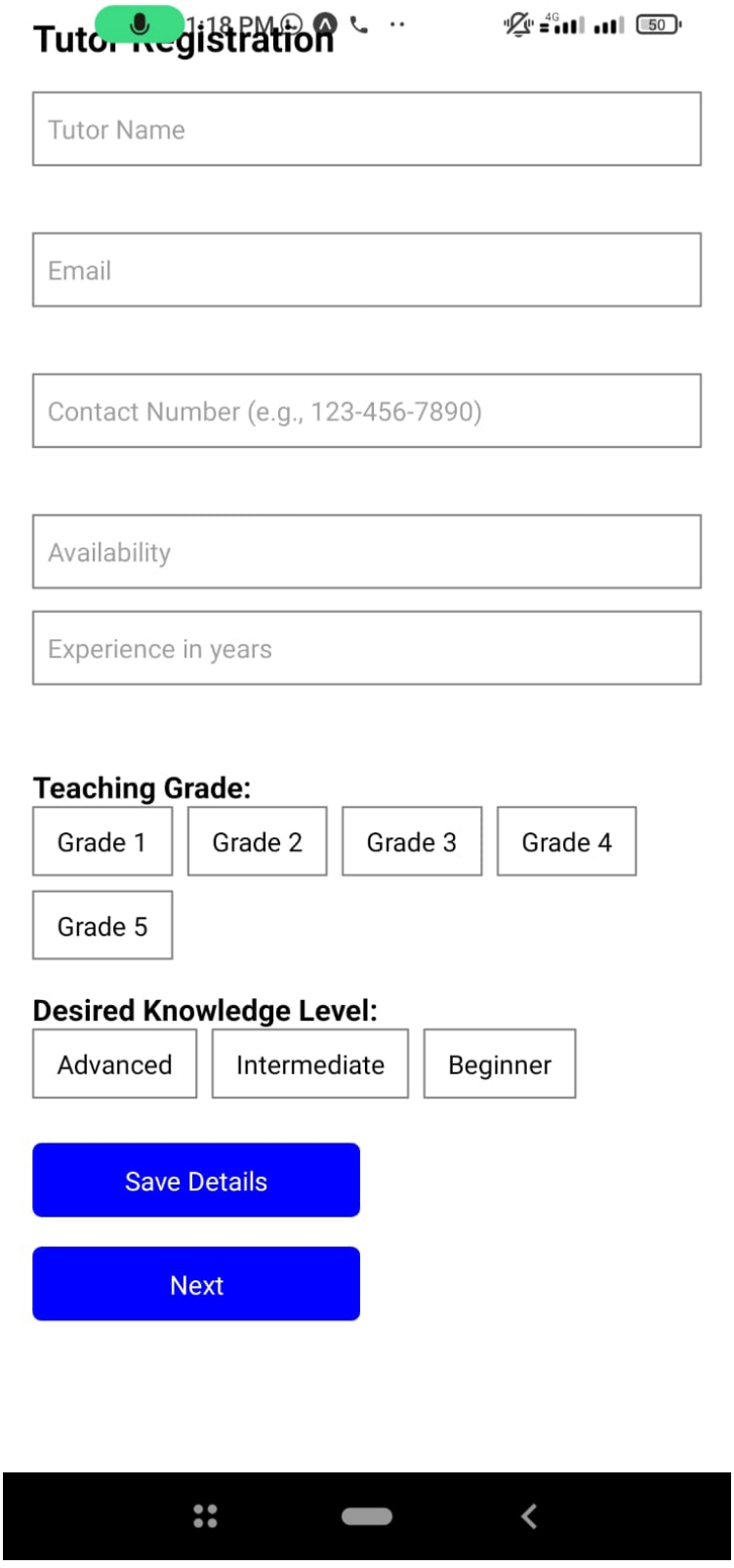


Figure 11 Tutor profile

6.4 Gaming modules interface (UI)

Figure 12 Gaming modules Home

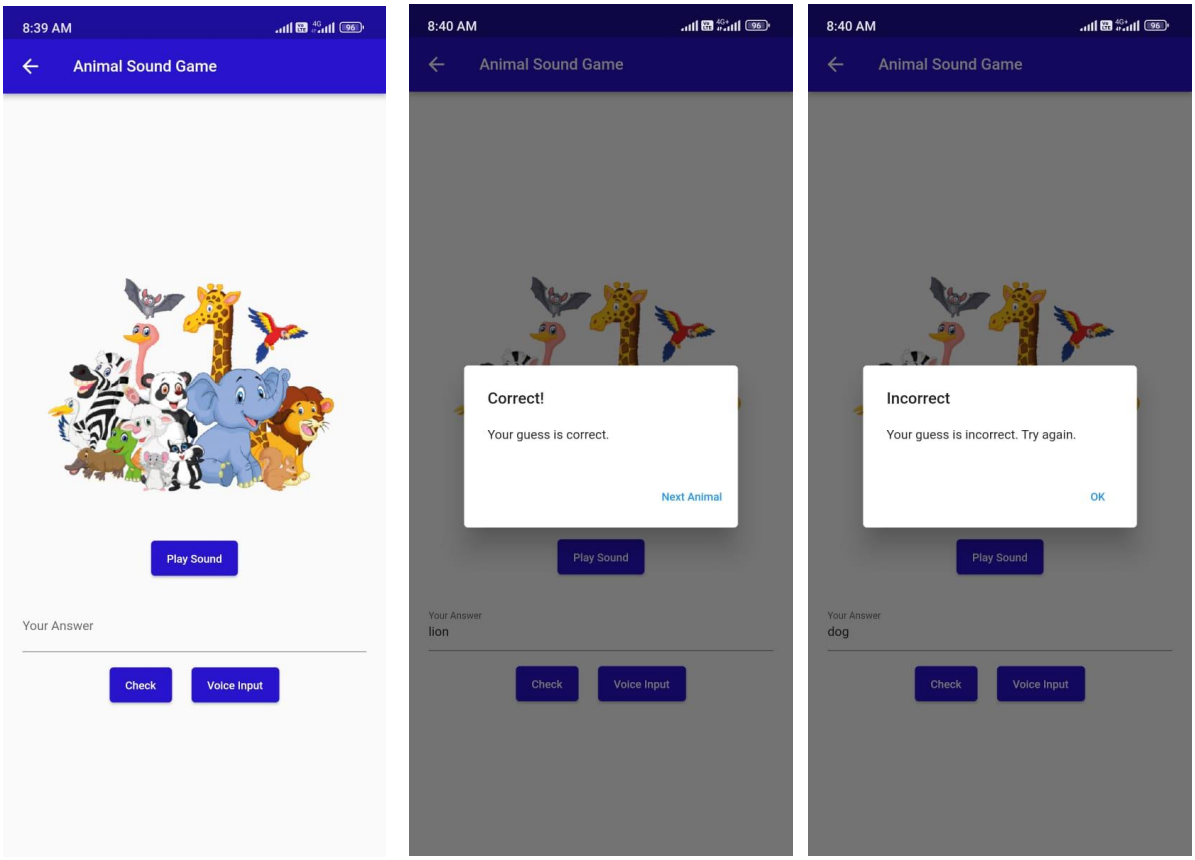


Figure 13 Animal sound game interface

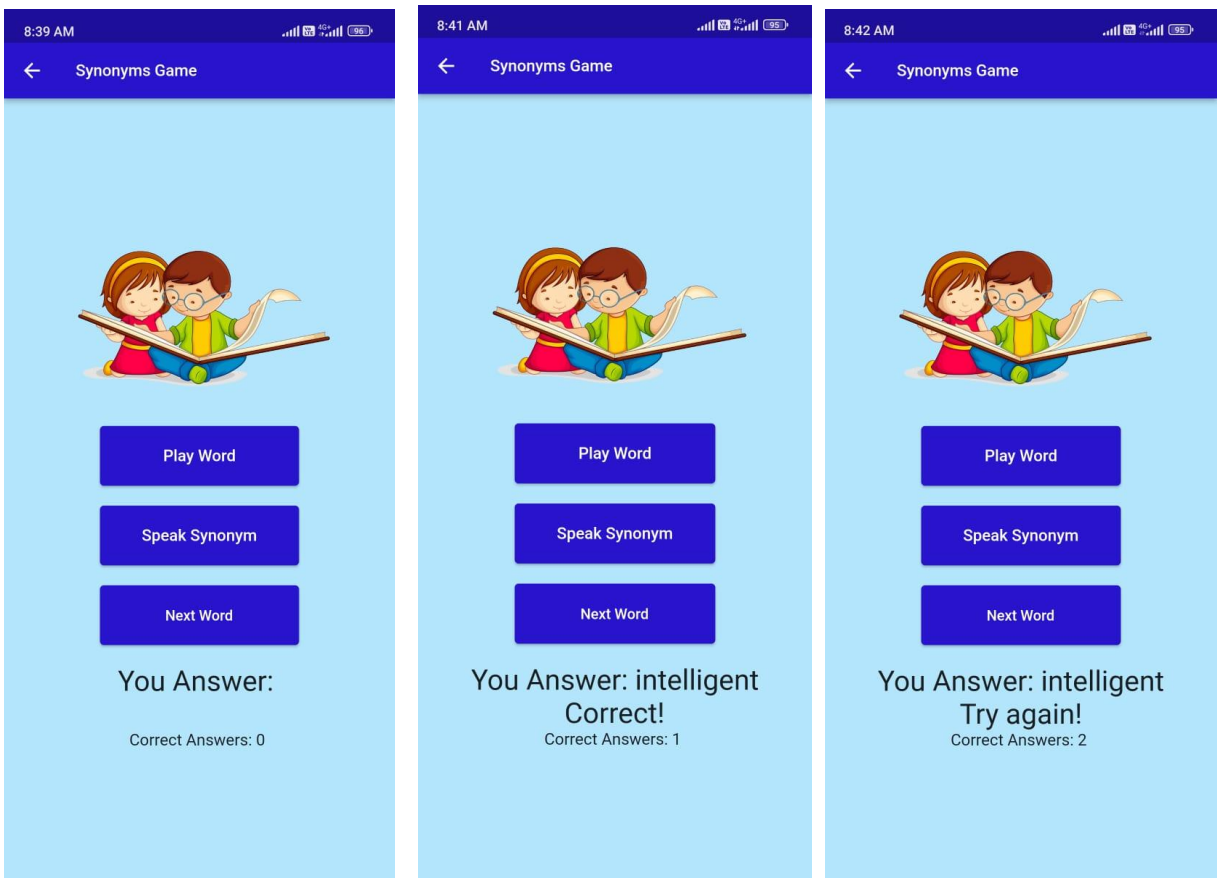


Figure 14 Synonyms game interface

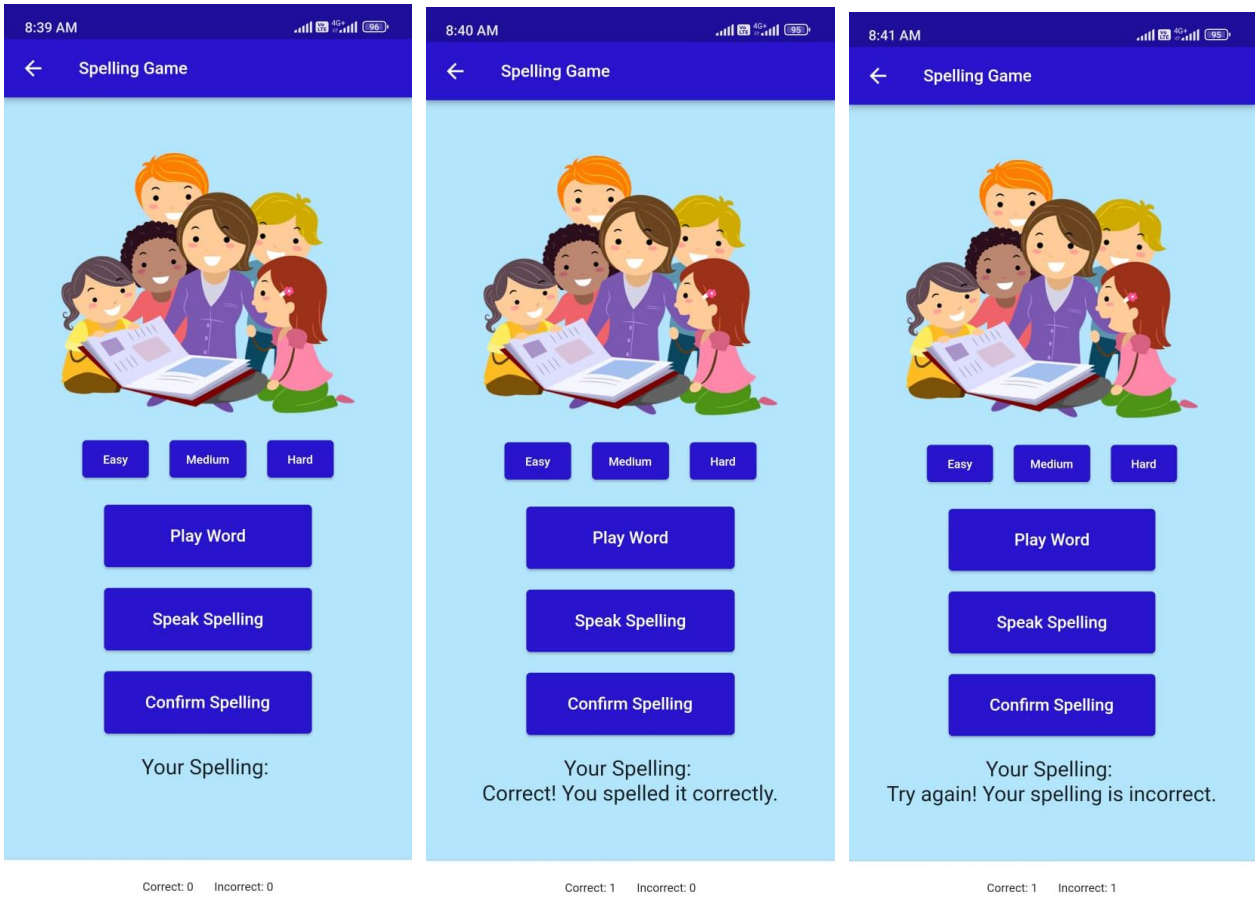


Figure 15 Fun spelling game interface

6.5 Tutor recommendation interface (UI)

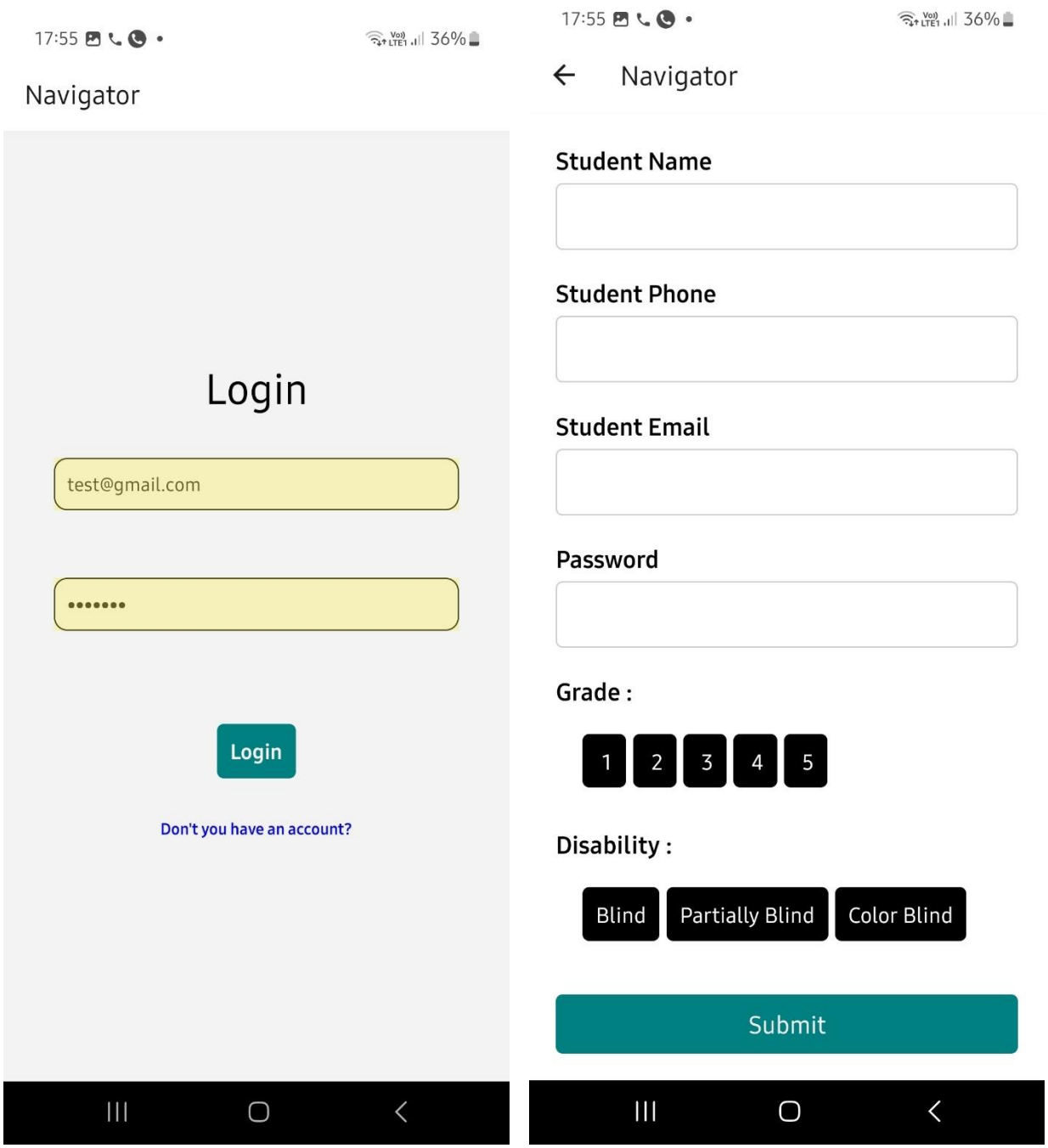


Figure 16 Login and Registration

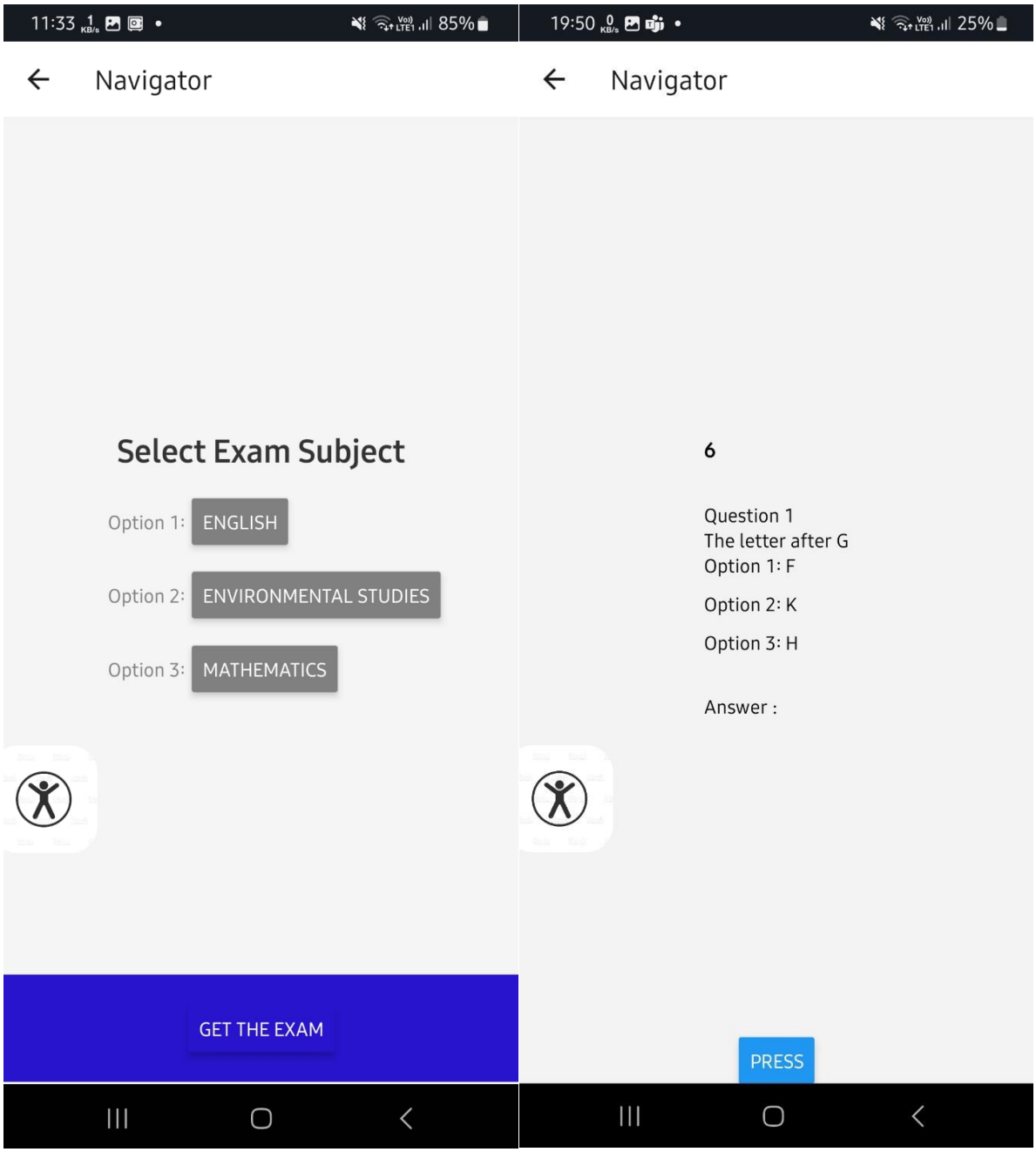


Figure 17 Subject selection and Exam page

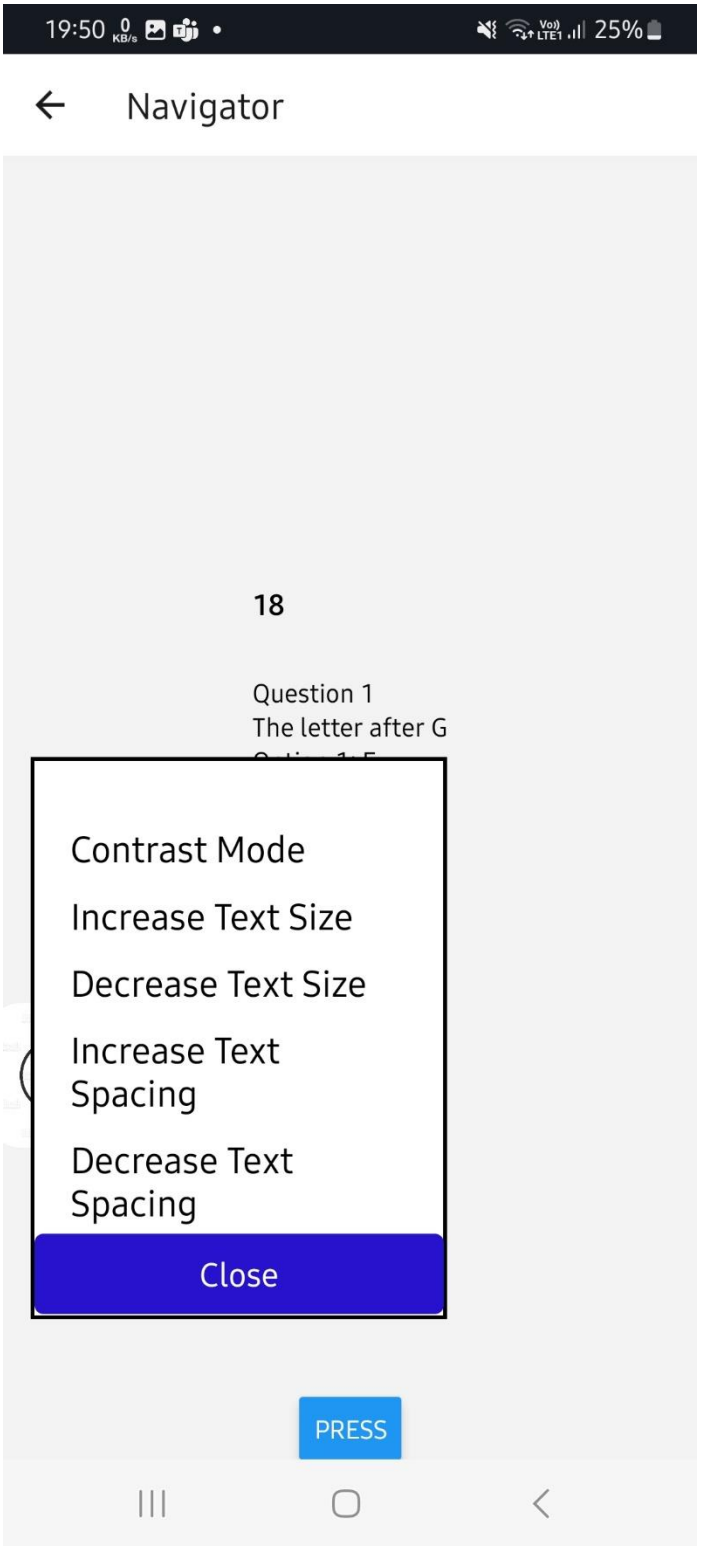


Figure 18 Accessibility mode

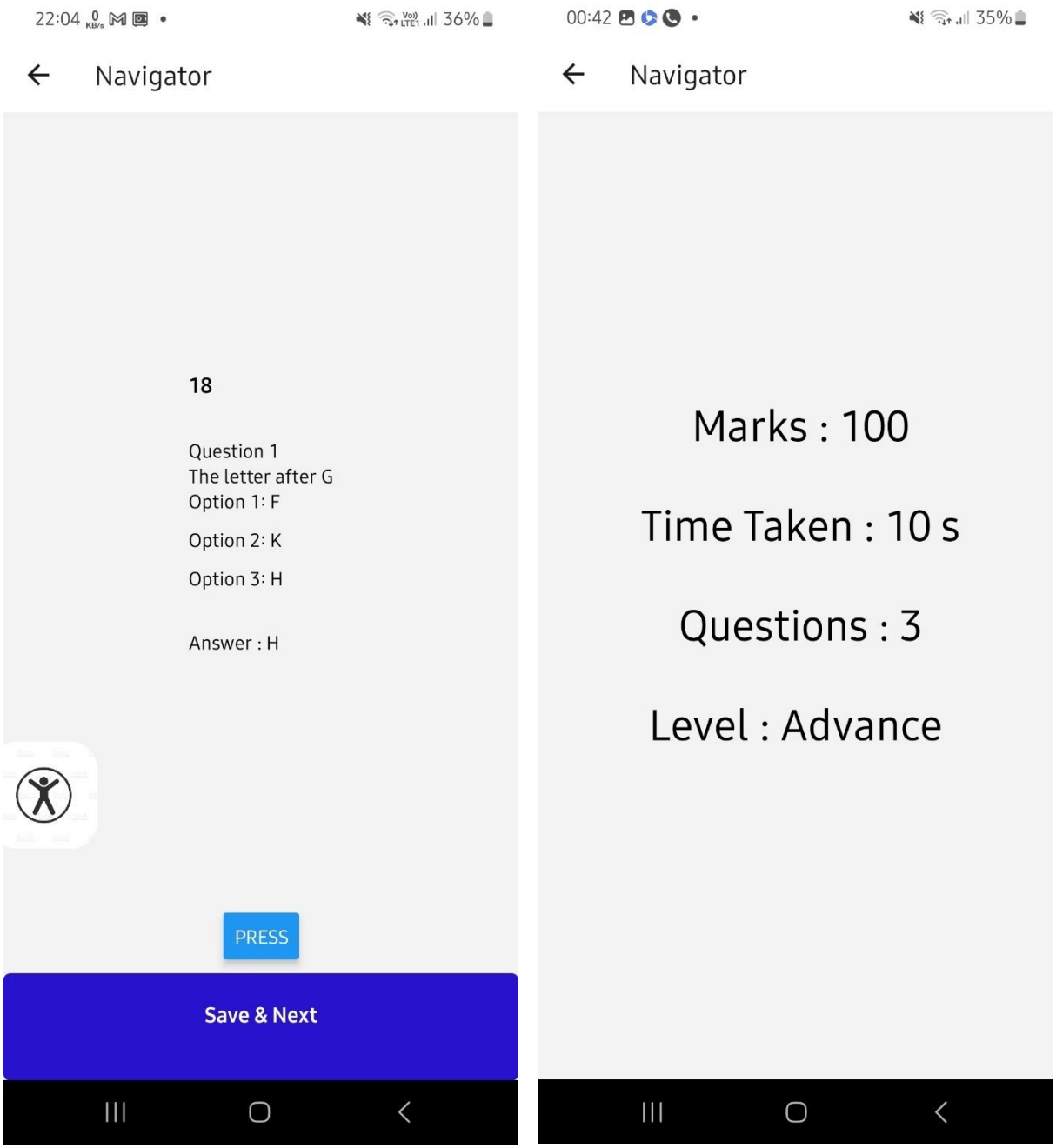


Figure 19 Answer & save button (after answering) and Results.

7. Result and Discussion

We conducted a physical survey at Ratmalana School for the Blind, involving 10 primary students, to measure the feasibility, effectiveness, and student engagement with visually impaired students.

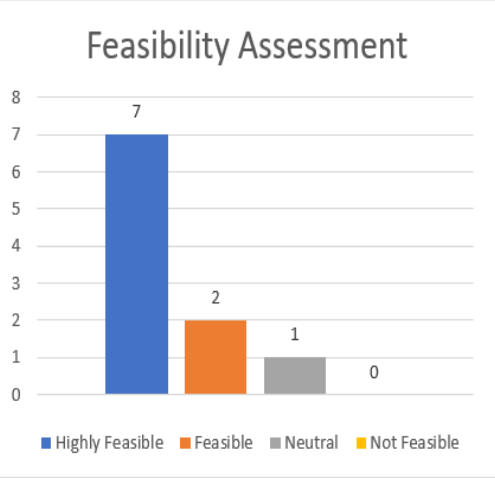


Figure 20 Feasibility of the developed e-learning system for visually impaired students in addressing their unique educational needs.

Most of the students (70%) found the e-learning application (Edu Sense) to be highly feasible, while 20% considered it as feasible. Only 10% of the students assumed a neutral stage, and none of the students responded as not feasible.

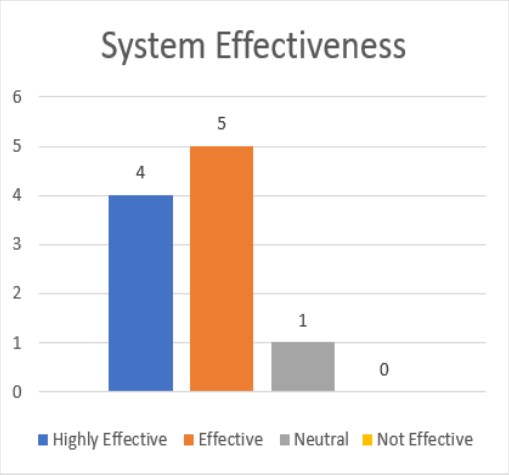


Figure 21 To what extent do you believe the e-learning system effectively addresses the educational requirements of visually impaired students while considering their specific challenges?

Most of the students (50%) found the e-learning application (Edu Sense) to be Effective, while 40% considered it as Highly Effective. A neutral stage was assumed by only 10% of the students, and none of them responded as not being effective.

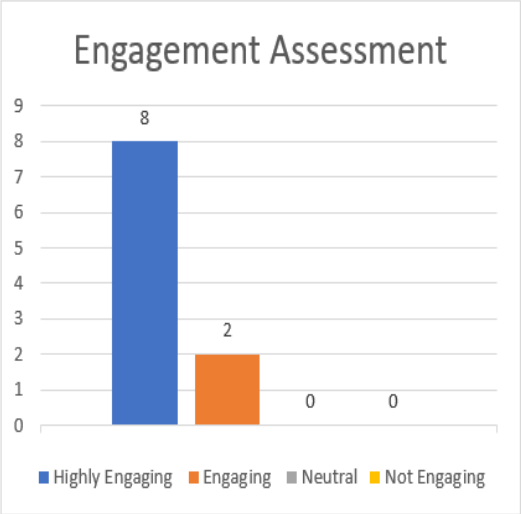


Figure 22 How effectively does the e-learning system engage visually impaired students in their learning journey?

Most of the students (80%) found the e-learning application (Edu Sense) to be highly Engaging, while 20% considered it as Engaging. None of the students responded as Neutral or not Engaging.

Table 2 Features comparison; R1: Proposed system; R2: Research 1[6]. R3: Research 2[7]; R4: Research 3[11]; R5: Research 3[15]

Features	R1	R2	R3	R4	R5
Speech-based tutor suggestion module	✓	✗	✗	✗	✗
Speech-based gaming module	✓	✗	✗	✗	✗
Accessibility modes in UI design	✓	✓	✓	✗	✓
Voice input and response capabilities	✓	✓	✓	✓	✓
Supportive voice bot for multilingual languages	✓	✗	✗	✗	✗
Voice-based calculator	✓	✗	✗	✗	✗

By incorporating the available features such as a speech-based tutor suggestion module, a speech-based gaming module, accessibility modes in UI design, voice input and response capabilities, a supportive voice bot for multilingual languages, and a voice-based calculator, we can ensure that the proposed research stands out as more effective compared to another existing research.

We are confident that our e-learning application has achieved success and effectively fulfilled the main objectives of this research based on the insights gathered from this survey.

The findings from the study are thoroughly analyzed and explained in this part. It investigates the significance of the findings regarding the study's goals and offers insights into the efficiency and usefulness of the created e-learning system for primary students with visual impairments.

The results emphasize the value of specialized e-learning programs for students who are blind or visually impaired. With equal opportunities for visually impaired students, according to the platform's positive effects on engagement and independent learning, inclusive education is significantly impacted. As a summary of findings, the study showed that the e-learning platform produced positive results, with visually challenged students expressing satisfaction and participation. The process of education was improved by the addition of a supportive voice bot, voice-based calculator, game modules and the recommendation of tutors based on knowledge and disability level.

The success of the platform to promote independent learning and create a sense of empowerment aligns with the study's goals. An inclusive learning environment was achieved through voice-based interactions and adaptive features that responded to the special needs of visually impaired pupils.

A relatively small sample size and the study's concentration on a particular age group (6 to 10 years) have limited its ability to be applied. Self-reported data may involve response bias, requiring attention to how the results are interpreted.

Future studies should examine a larger, more varied sample, considering different age groups and educational levels. And the premier features should be added to the application. We develop iOS applications as well.

The proposed e-learning platform could satisfy the needs of elementary school children who are blind or visually impaired. Further research and ongoing development are required to increase its efficiency and accessibility given its positive effects on engagement, independence, and inclusive education.

8. Commercialization of the Product

Our mobile application has been developed to accommodate the requirements of visually impaired learners to help them in successfully completing their academic journeys. Our intended audience includes the parents or guardians of visually impaired primary students, primary schools that serve these students, and organizations that help the community of the blind. We want to use social media channels to advertise our goods to the widest possible audience of potential customers.

We are interested in using a number of revenue-generating techniques to market the product. These might involve adding a price to the application itself, charging for premium features, or making money from in-app advertisements. We are aware that the community of people who are blind has particular needs, and we have added a number of features to meet those needs. With features like text-to-speech and audio explanations of the pictures, our program is intended to be user-friendly and accessible.

We want to use social media communications to promote our product in order to make it stand out in the marketplace. In order to reach our target audience, we produce powerful materials that highlight the benefits of our product. As part of our social media plan, we'll build a strong brand identity, interact with potential clients, and inform our audience of any application changes or new features.

In conclusion, our mobile application is intended to help visually challenged students, and we think it has a lot of promise for the business world. We're convinced that with the help of our revenue-generating plans and social media marketing, we can connect with our target market, bring in money, and enhance the lives of visually impaired students.

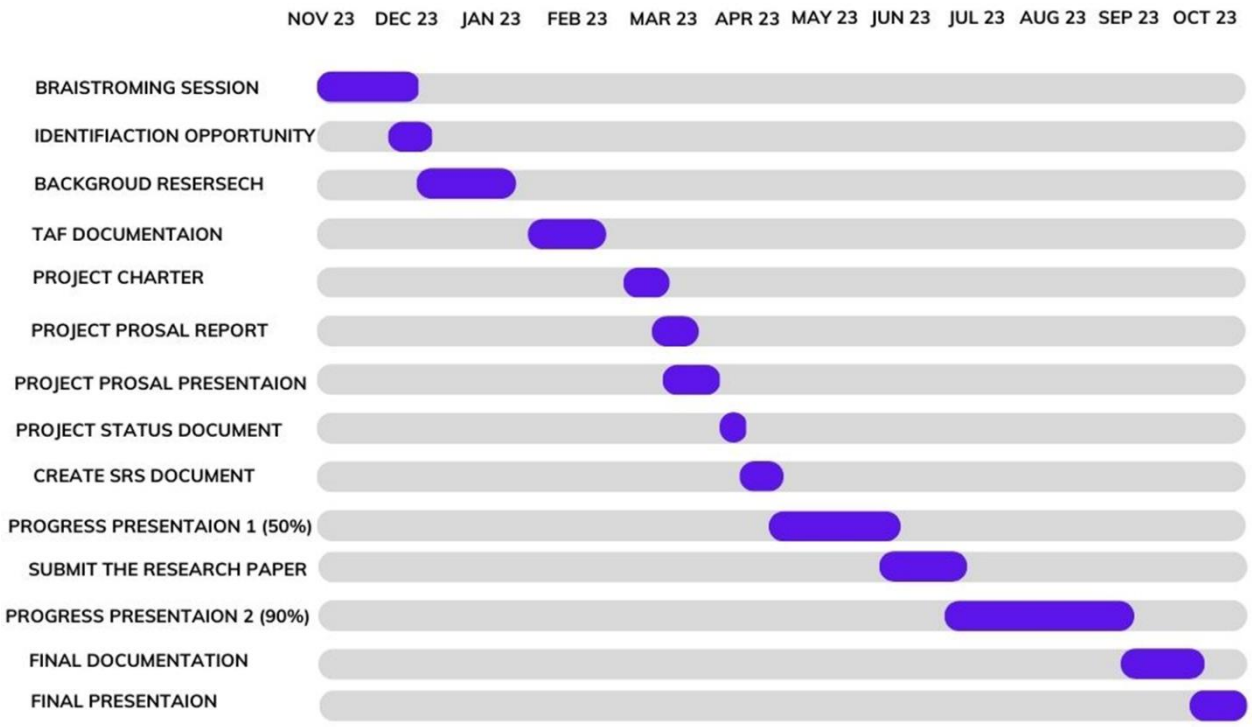
9. Conclusions

The research endeavor at hand is geared towards revolutionizing the online learning experience for visually impaired elementary school children. The overarching objective of this comprehensive solution is to enhance their access, engagement, and overall effectiveness in the realm of education. This multifaceted approach encompasses the development of a supportive voice bot, a user-friendly voice-based calculator, an engaging gaming module, and a tutor recommendation system. The primary research contribution lies in the thoughtful execution and integration of these components to address specific challenges faced by visually impaired learners.

The creation of the supportive voice bot takes center stage, catering to a multilingual audience by leveraging natural language processing techniques. This empowers learners to engage in seamless interactions across languages, ensuring an inclusive learning environment. The innovative voice-based calculator module further enriches the application, providing an intuitive tool for mathematical calculations through voice input or touch interactions. This integration signifies the application's commitment to accessibility and its potential to significantly ease the learning journey for visually impaired students. The gaming module introduces an interactive dimension to the learning process, with three distinct voice-based games designed to entertain, educate, and engage users. By sourcing animal sounds, curating word databases, and integrating voice recognition, the games not only foster interest in studies but also provide informative feedback, promoting a holistic learning experience. The methodology further introduces a tutor recommendation system, which leverages technology to match visually impaired learners with suitable tutors based on their knowledge levels and disabilities. This component aims to provide personalized support, promoting an inclusive and supportive learning atmosphere.

The application's overall contribution rests in its successful synthesis of cutting-edge technologies, including natural language processing, speech recognition, and user-friendly interfaces, to create an ecosystem that caters to the unique needs of visually impaired students. The thoughtful integration of these components addresses the outlined sub-objectives, creating an application that aims to transform the way visually impaired learners engage with educational content, enhance their skills, and foster an enduring interest in studies.

10. Gantt Chart



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12. Appendices

Figure 23 Ratmalana Blind College image 1

Figure 24 Ratmalana Blind College image 2

We went to Ratmalana Blind College to gather information. We were able to learn a lot of information from there.

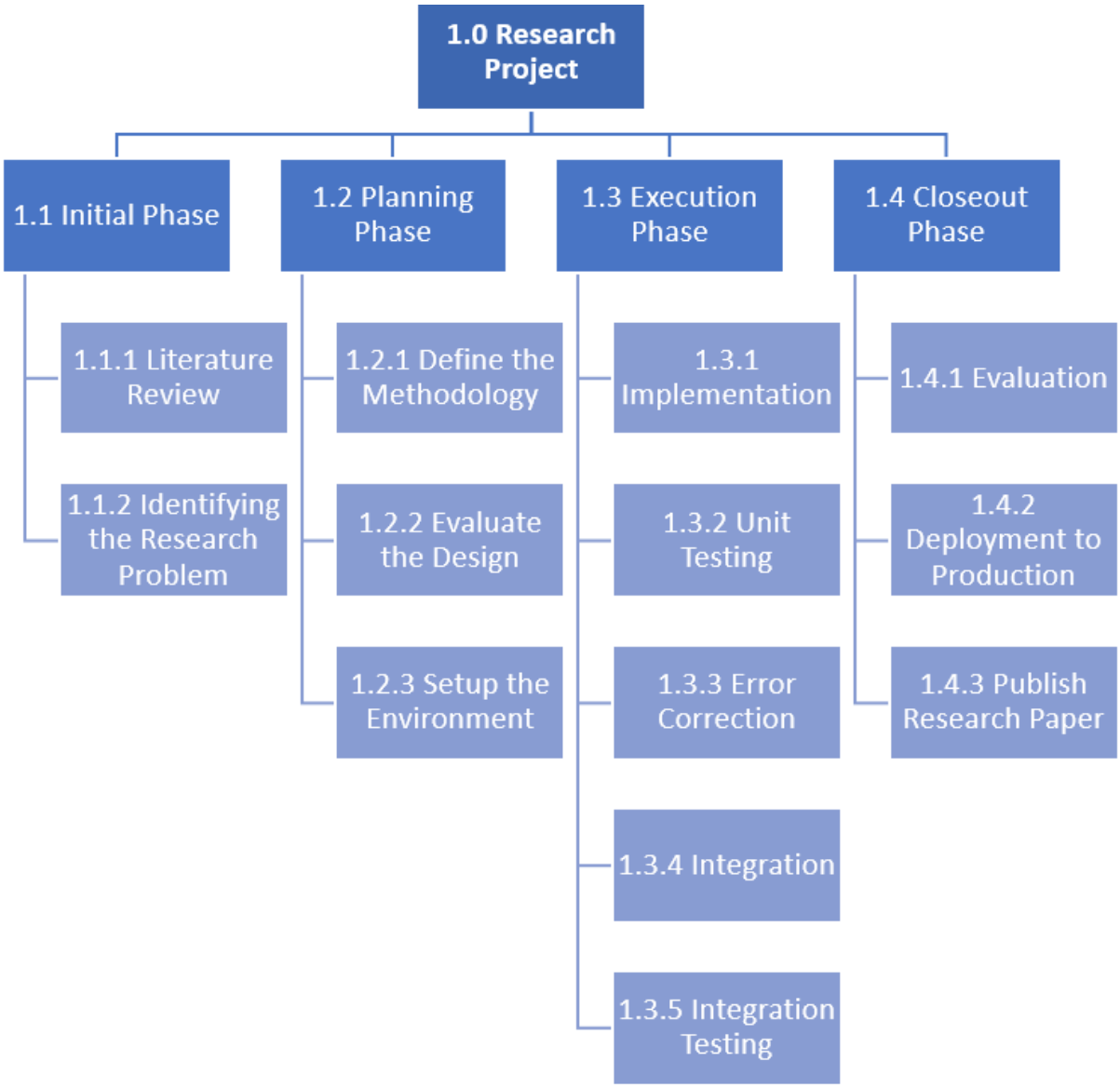

Figure 25 Work breakdown structure

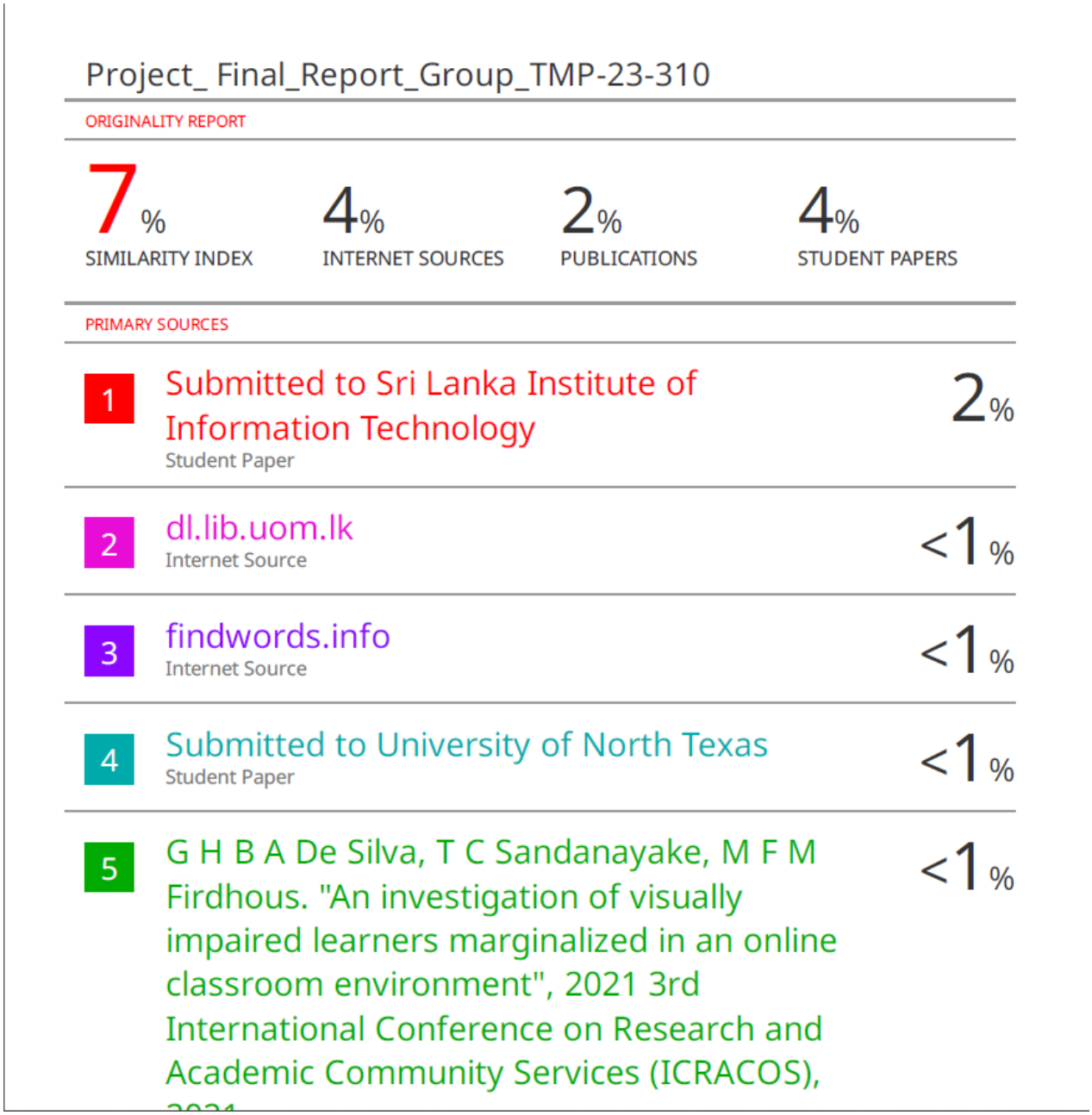

Figure 26 Turnitin report