Web Application for Dyslexic Students

Dr. Gresha Bhatia, Juhi Birare, Samruddhi Jatkar, Aiman Dabir

Department Of Computer Engineering
Vivekanand Education Society's Institute of Technology, Mumbai 400074, India
Email – gresha.bhatia@ves.ac.in
2022.juhi.birare@ves.ac.in
2022.samruddhi.jatkar@ves.ac.in
2022.aiman.dabir@ves.ac.in

Abstract: **The web application designed to support individuals with dyslexia offers a personalized and accessible learning environment powered by artificial intelligence (AI), addressing the unique learning challenges faced by dyslexic users. It features adaptive tools, multimedia resources, and a personalized profile page that tracks progress and customizes learning plans based on individual needs. The app's interactive components, such as audio and video lessons, cater to different learning styles, while a text-to-speech tool transforms written content into spoken words, enhancing comprehension and reducing cognitive load. Additionally, educational games promote active engagement, making learning more dynamic. Comprehensive progress tracking allows students and educators to monitor development, identify strengths and areas for improvement, and adapt learning strategies. This innovative approach fosters a flexible, interactive, and tailored educational experience for dyslexic learners.**

Keywords: Dyslexia, Accessible Learning, Artificial Intelligence (AI) Adaptive Tools, Personalized Learning, Text-to-Speech, Multimedia Resources, Progress Tracking, Learning Disabilities, Auditory Learning, Educational Technology.

I. INTRODUCTION

Dyslexia is a widespread learning disability that significantly affects an individual's ability to read, spell, and decode words with accuracy and fluency, leading to notable challenges in traditional educational settings. These difficulties often result in a slower pace of learning and can impact a student's self-esteem and motivation. To address these unique learning challenges, there is a pressing need for innovative educational approaches that can better support dyslexic learners by adapting to their specific needs. This research paper introduces a web application that leverages artificial intelligence to transform educational content delivery, making it more accessible and tailored for individuals with dyslexia. The app utilizes real-time progress data to dynamically adjust the learning experience, ensuring that educational content is personalized according to each user's unique pace and areas for improvement. By celebrating milestones and achievements, it also promotes a motivating learning environment that encourages continued progress.

The application goes beyond conventional teaching methods by incorporating customized learning plans that cater to various learning preferences, including auditory, visual, and kinaesthetic styles. These plans feature a diverse range of multimedia resources, such as audio and video lessons, to present complex topics in more accessible formats, enhancing engagement and comprehension. A built-in text-to-speech tool converts written text into spoken words, which is particularly beneficial for dyslexic learners who may struggle with processing written information as quickly as their peers. This feature enables users to access content in an auditory form, reducing the cognitive load associated with reading. By integrating AI-driven, adaptive strategies, the application advocates for a more inclusive approach to education, fostering an environment where all learners can thrive despite their learning differences. Through personalized, interactive, and flexible solutions, the web application aims to empower dyslexic students and contribute to a more equitable educational landscape.

II. PROPOSED IDEA

The proposed research introduces a comprehensive web application designed to address the educational challenges experienced by individuals with dyslexia by offering an adaptive, user-centred solution that supports diverse learning needs. This application aims to create a supportive educational environment by integrating the latest advancements in artificial intelligence, multi-sensory learning techniques, and adaptive content delivery. By accommodating different learning preferences, such as auditory, visual, and kinaesthetic styles, the app seeks to transform traditional educational methods, making them more inclusive and effective for dyslexic learners. The platform also provides valuable resources and tools for educators and parents, enabling them to better support students with dyslexia.

At the core of the proposed system are AI-driven personalized learning paths that adjust dynamically based on user performance, ensuring that content is tailored to each learner's unique pace and needs. These individualized plans include various multimedia resources such as video lessons, audio content, interactive exercises, and educational games, which aim to present complex topics in engaging formats that enhance understanding and retention. The multi-sensory approach ensures that content is accessible to a wider range of learners by using a combination of text, speech, visual aids, and animations to reinforce key concepts. Comprehensive progress tracking and real-time feedback further allow for continuous monitoring of student development, providing detailed reports that identify strengths, growth trends, and areas needing improvement.

The application also features training resources and awareness programs to support educators and parents in understanding dyslexia and adapting teaching methods accordingly. These include instructional videos, best practices for classroom modifications, and guidelines for using assistive technology effectively. A built-in community platform facilitates shared learning and collaboration, enabling students, families, and educators to connect, exchange experiences, and participate in group activities. By integrating these components, the proposed web application offers a dynamic, inclusive, and effective educational platform that empowers dyslexic learners, promotes academic growth, and fosters a more accessible educational landscape for all.

III. METHODOLOGY

The methodology employed in this paper outlines a systematic approach to developing a web application tailored for dyslexic learners, emphasizing the creation of personalized, adaptive, and interactive educational experiences. The development process consists of several key phases: planning, development, testing, review, and improvement, with a focus on leveraging artificial intelligence (AI) to ensure that the platform meets the evolving needs of its users.

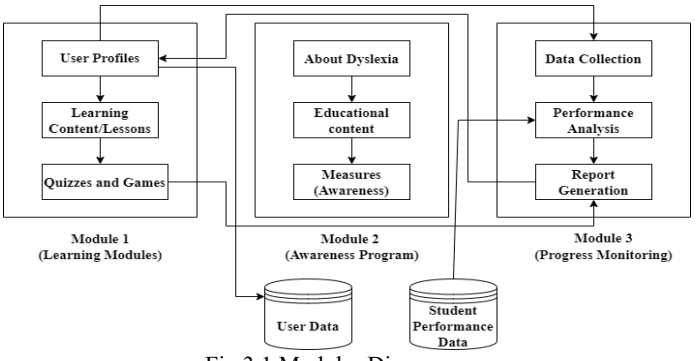

Fig 3.1 Modular Diagram

1. User Profile Development and Customized Learning Plans: The initial phase involves designing a user-friendly profile page that tracks academic progress and highlights areas needing improvement. This profile serves as the foundation for creating personalized learning plans, which are developed using AI algorithms to analyze user data. These plans include tailored audio and video lessons, as well as adaptive content that evolves based on the learner's progress, providing a dynamic and individualized learning experience. The AI integration continuously assesses performance, adjusting learning paths in real-time to deliver targeted feedback and support, thereby enhancing user engagement and outcomes.

2. Interactive Modules and Continuous Improvement: The application incorporates interactive modules such as text-to-speech tools and educational games to reinforce key concepts and accommodate different learning preferences. This multi-sensory approach ensures a more engaging and effective learning experience for dyslexic users. The platform is developed iteratively using agile methodologies, allowing for rapid prototyping and testing of features. User feedback is collected at each stage to refine the AI models and learning materials, ensuring that the application remains responsive to learner needs and optimizes educational outcomes.

3. Ongoing Support and Maintenance: A continuous improvement strategy is employed to ensure the platform's long-term success. Regular reviews are conducted to evaluate whether the features align with the project's objectives and desired user impact. The feedback loop informs updates to the backlog, enhancing functionality based on user input and performance metrics. The platform is maintained through consistent updates, bug fixes, and enhancements to deliver a stable, adaptive, and inclusive learning environment. By integrating these methodological steps, the research aims to provide a flexible and effective educational solution that empowers dyslexic learners through personalized, AI-driven learning experiences.

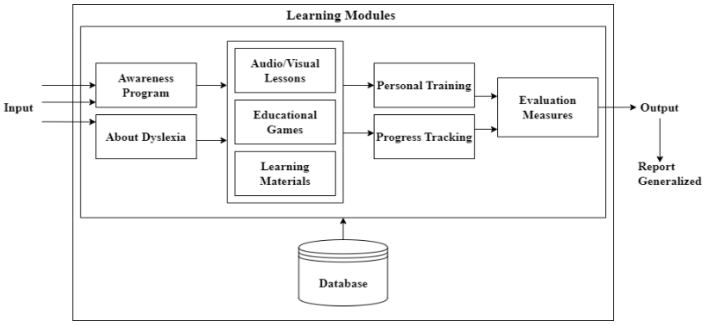

Fig 3.2 Block Diagram

4. Handwriting Model Analysis for Dyslexia Detection

To enhance the personalized learning experience for dyslexic learners, the system integrates a deep learning-based handwriting analysis model that identifies patterns commonly associated with dyslexia. This model is designed to analyze both handwritten text images and text-based linguistic features to provide targeted learning interventions. By leveraging computer vision and natural language processing (NLP), the system can detect inconsistencies in handwriting and offer adaptive learning recommendations to help learners improve their writing skills.

4.1 Real-Time Handwriting Processing and Classification

The system follows a structured pipeline to ensure accuracy and efficiency in handwriting analysis:

1. Handwriting Submission & Preprocessing:

Users upload images of handwritten text, which the system preprocesses by resizing to 224×224 pixels, converting to grayscale, and applying noise reduction techniques (such as Gaussian filtering). Text detection techniques, such as Optical Character Recognition (OCR), may be employed to extract text from images for further linguistic analysis.

2. Feature Extraction & Representation:

The CNN extracts spatial handwriting features, such as stroke variations, letter distortions, irregular spacing, and inconsistent word formations. Linguistic features, including letter reversals, spelling mistakes, writing speed variability, and inconsistencies in word structure, are extracted from text annotations.

3. Classification & Dyslexia Detection:

The model predicts whether the handwriting exhibits dyslexic characteristics, outputting a probability score. The binary classification model assigns a probability score (ranging from 0 to 1), determining whether a learner's handwriting is likely dyslexic. If required, a multi-class classification approach can be implemented to detect the severity level of dyslexic handwriting patterns.

4. Personalized Feedback & Adaptive Learning:

Based on classification results, users receive real-time feedback on their handwriting, including error analysis and recommendations. The system suggests adaptive exercises such as handwriting drills, spelling corrections, phonemic awareness tasks, and stroke refinement activities. Educators or parents can access the analysis report to track progress over time and modify learning strategies accordingly.

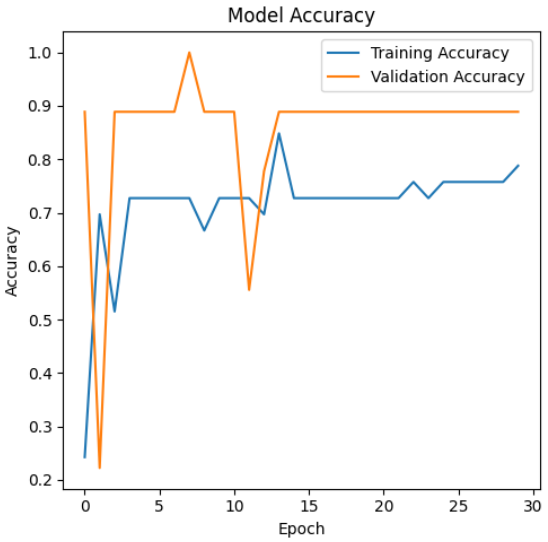

Fig 3.3 Model Accuracy

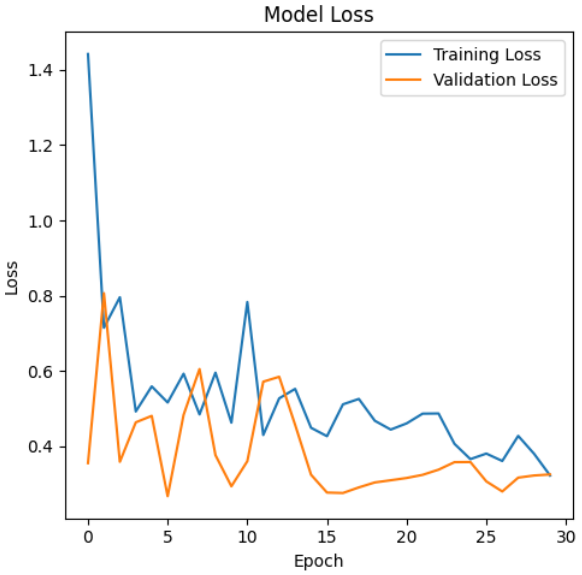

Fig 3.4 Model Loss

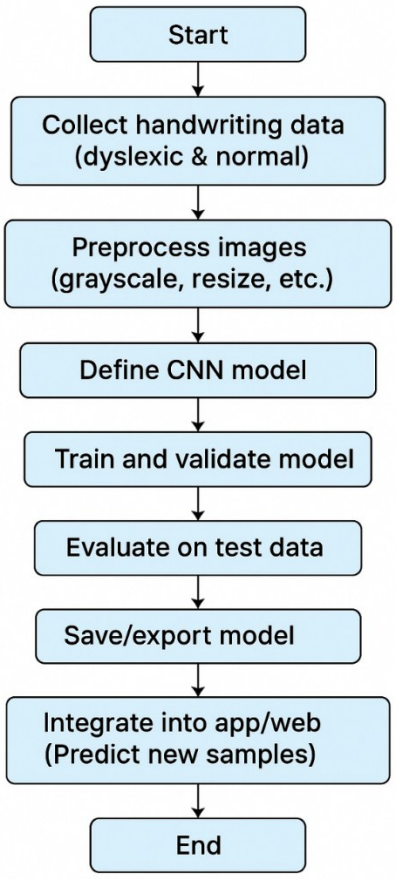

Fig 3.5 Handwriting Analysis Flowchart

IV. IMPLEMENTATION

The implementation of the proposed web application involves the development of a user-friendly frontend and the integration of advanced accessibility features designed to support dyslexic learners. The application consists of several key pages, including Home, Learn, and About Us, each contributing to a cohesive user experience. The integration of Text-to-Speech (TTS) and Speech-to-Text (STT) APIs is central to enhancing accessibility and facilitating communication for dyslexic students, providing them with valuable tools to aid in reading and interactive learning tasks.

1. Frontend Development and Features

The Home page serves as the main navigation hub, allowing users to access key modules effortlessly. The Learn page incorporates the TTS functionality, which reads learning materials aloud, thereby accommodating auditory learners and supporting comprehension. The STT feature is also integrated into this page, enabling users to engage in interactive voice-based tasks that foster active participation. Meanwhile, the About Us page is designed to deliver essential static information and contact details effectively, ensuring that users have access to relevant background about the application.

2. Functionality and Feature Testing

The functionality of the TTS feature was thoroughly tested, revealing its effectiveness in reading text displayed on the Learn page with clear and natural speech output. Although it handled a variety of sentence types well, minor challenges were noted in the pronunciation of certain special characters. The STT feature exhibited reliable performance, accurately converting speech input into text, particularly with common phrases.

3. Performance Evaluation and Future Improvements

The performance evaluation demonstrated that the frontend loads quickly, with responsive transitions between pages. The TTS API responded within 3-4 seconds of text input, providing nearly instantaneous feedback to users, while the STT feature achieved an average response time of 2-3 seconds, depending on the clarity and length of the speech input.

The handwriting analysis model was evaluated using key performance metrics to assess its effectiveness in identifying handwriting issues commonly associated with dyslexic learners. The results are as follows:

- Accuracy: 0.8889
- Precision: 0.8889
- Recall: 1.0000
- F1-Score: 0.9412

The model shows high reliability with perfect recall in detecting handwriting errors and a strong F1-score indicating balanced performance. This ensures accurate and timely support for dyslexic students through effective handwriting analysis.

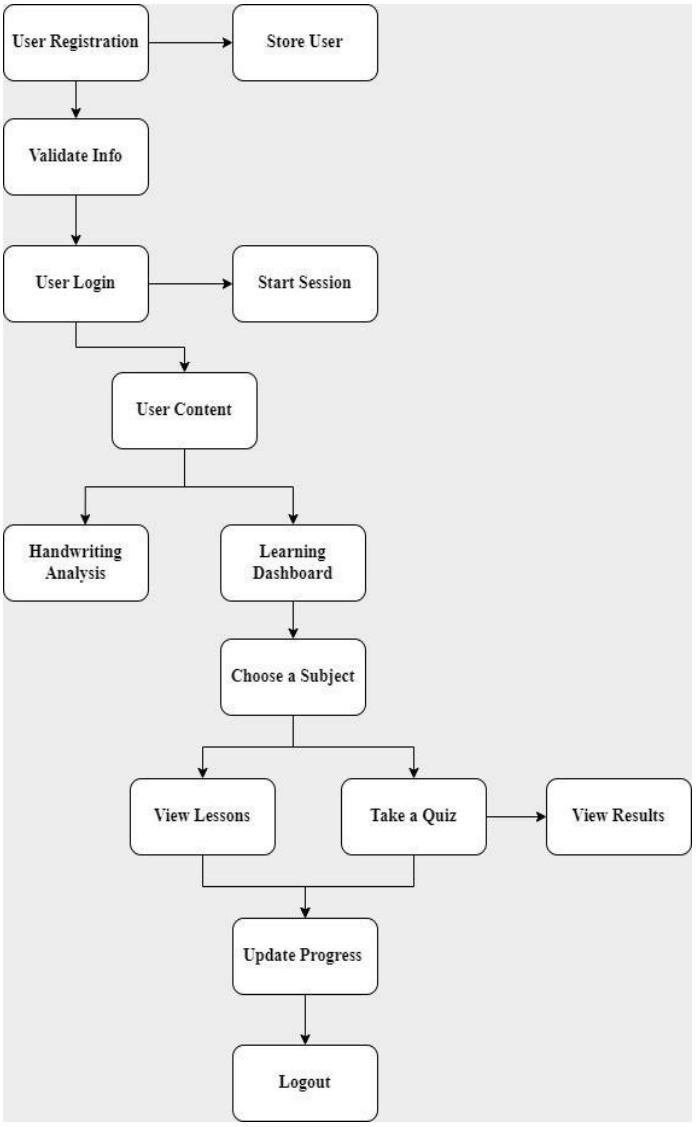

Fig 4.1 Architectural Framework

V. RESULTS

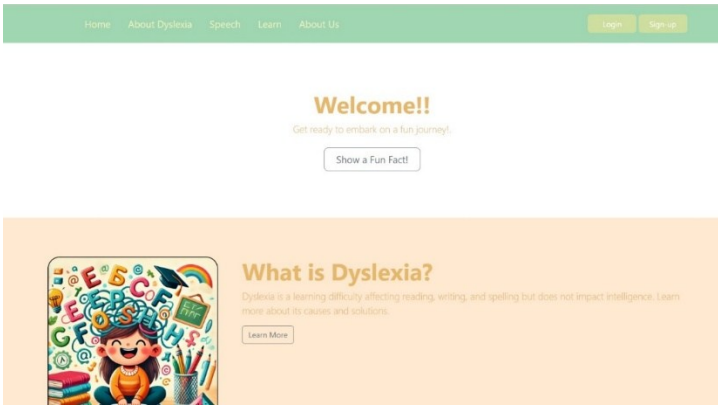

Fig 5.1 Home Page

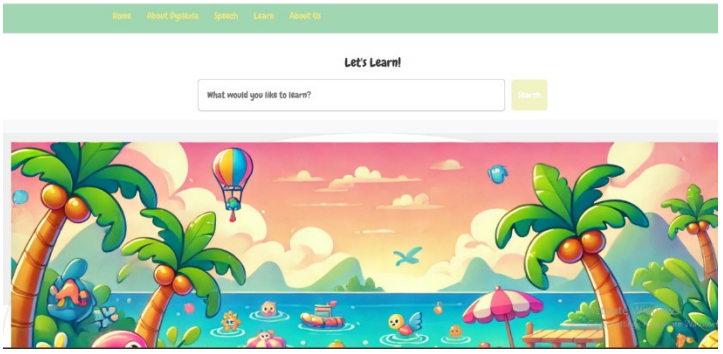

Fig 5.2 Learn Page

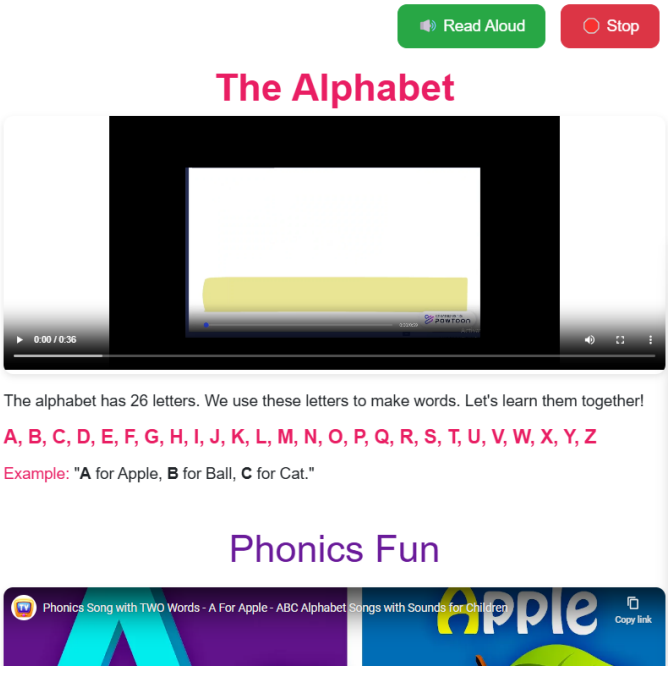

Fig 5.3 Phonics Page

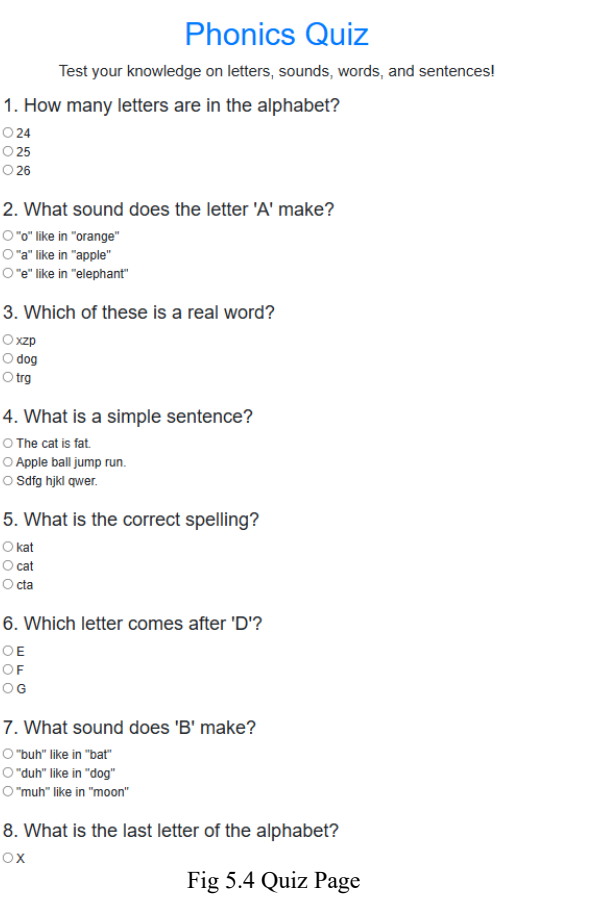

Fig 5.4 Quiz Page

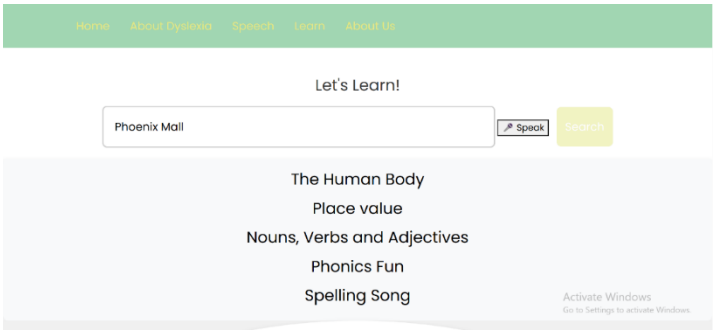

Fig 5.5 Search Page

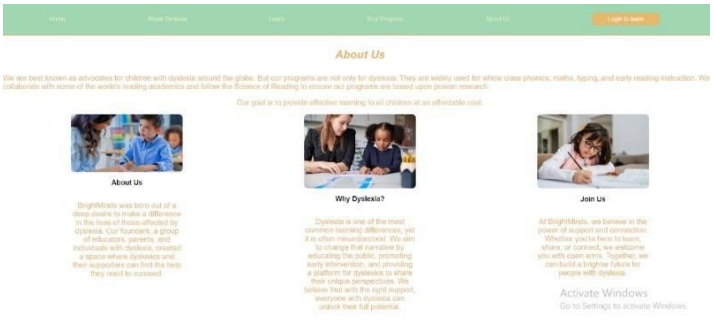

Fig 5.6 About Us Page

VI. CONCLUSION

The development of the web application designed to support dyslexic students has demonstrated significant advancements, particularly with the successful implementation of the frontend and the integration of Text-to- Speech (TTS) and Speech-to-Text (STT) APIs. These features enhance accessibility by enabling students to listen to educational content and convert spoken language into text, thereby facilitating a more engaging learning experience. Preliminary testing indicates positive outcomes in usability, functionality, and system responsiveness, underscoring the application's potential to transform educational access for dyslexic learners.

While the current iteration is operational, further work is essential to fully realize the project's scope. Planned enhancements, including handwriting error detection and speech confidence prediction, will be critical in improving the application's effectiveness. Overall, the initial results affirm that the system is well-positioned to make learning more inclusive and accessible for dyslexic students, yet continued refinement and the addition of targeted features will be necessary to maximize its impact in educational settings.

VII. FUTURE WORK

Thus, further in the research, we aim to complete the development and integration of models for handwriting error detection and speech confidence prediction. These models will provide personalized assessments by identifying errors in students' handwriting and gauging their confidence during speech-based tasks. The integration of such advanced models is expected to enhance the overall learning experience by offering targeted feedback, helping students refine their skills in both written and spoken tasks. Moreover, refining the accuracy of the Text-to-Speech (TTS) and Speech-to- Text (STT) APIs will be a priority, ensuring that the system can effectively recognize diverse accents and speech patterns, improving its adaptability for students from varied linguistic backgrounds.

Further work will also focus on enhancing the progress tracking and feedback mechanisms, which will allow students to monitor their learning journey in greater detail. By providing personalized insights based on students' performance in various tasks, this feature will help tailor learning pathways that address individual needs. Additionally, we plan to fully implement the learning modules, expanding the range of personalized exercises and assessments available. This expansion will ensure that students receive diverse and adaptive content, aligning with their evolving skill levels and fostering continuous improvement.

VIII. REFERENCES

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