DYSLEXIAID: AN AI-POWERED MULTI-MODAL LEARNING PLATFORM FOR REAL-TIME READING ASSISTANCE IN DYSLEXIC STUDENTS

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Introduction:

Dyslexia is a neurodevelopmental learning disability that affects reading, spelling, and word recognition, impacting nearly 5-15% of school-aged children worldwide. Despite its prevalence, many cases remain undiagnosed in early stages, leading to academic difficulties and reduced confidence among learners. Traditional teaching methods rely heavily on repetition and text-based instruction, which often fail to address the specific needs of dyslexic students and may result in frustration and disengagement.

Existing assistive technologies provide limited support through isolated features such as Text-to-Speech (TTS) or screening tools. However, these systems lack real-time intervention and do not offer an integrated learning environment. Most platforms fail to detect reading difficulties such as pauses or mispronunciations as they occur and do not effectively combine multiple input modalities such as speech, handwriting, and printed text.

To better understand these challenges, a field study was conducted at the Association for People with Disability (APD), Bengaluru. The study revealed that students often struggle to continue reading when encountering unfamiliar words and require immediate assistance. It also highlighted the importance of interactive learning and the need for measurable progress tracking for parents and teachers.

To address these gaps, DyslexiAid is proposed as an AI-powered learning platform that provides real-time reading assistance. The system integrates Speech-to-Text (STT), Text-to-Speech (TTS), and Optical Character Recognition (OCR), along with a real-time struggle detection mechanism based on pause analysis and Levenshtein distance.

Developed as a Progressive Web Application (PWA), the platform incorporates gamified learning and role-based dashboards. By combining real-time feedback, multimodal interaction, and data-driven insights, DyslexiAid aims to provide an effective, affordable, and scalable solution for supporting dyslexic learners.

Objectives:

1. To develop an AI-powered learning platform that assists dyslexic students in improving their reading skills.
2. To design a real-time reading aid capable of detecting pauses and mispronunciations during reading.
3. To provide immediate and non-intrusive assistance using Speech-to-Text (STT) and Text-to-Speech (TTS) technologies.
4. To integrate Optical Character Recognition (OCR) for supporting both printed and handwritten text inputs.
5. To incorporate gamified learning modules to enhance student engagement and motivation.
6. To implement role-based dashboards for students, parents, and teachers to track learning progress.

Methodology:

The proposed system, DyslexiAid, is designed using a three-tier architecture consisting of a frontend Progressive Web Application (PWA), an application layer with AI-based modules, and a cloud-based backend for data management. The platform integrates assistive technologies such as Speech-to-Text (STT), Text-to-Speech (TTS), and Optical Character Recognition (OCR) with gamified learning and performance tracking.

To understand the real-world challenges faced by dyslexic learners, a comprehensive field study was conducted at the Association for People with Disability (APD), Bengaluru. Through direct observation and interaction with dyslexic students, three critical learning needs were identified:

1. Students frequently experience reading hesitation when encountering unfamiliar words and require immediate assistance to continue reading fluently.
2. Interactive and reward-based learning mechanisms significantly enhance student motivation and sustained engagement.
3. Parents and teachers require measurable, data-driven insights to effectively monitor student progress and provide personalized support.

These findings directly influenced the design and development of DyslexiAid's core features, including the real-time Auto-Assist module for immediate struggle detection, gamified learning components to enhance engagement, and comprehensive role-based dashboards for continuous progress tracking and analysis.

The frontend is developed using ReactJS, providing a responsive and accessible interface. Accessibility features such as adjustable fonts, colour contrast, and font size are incorporated to support dyslexic learners. The system supports multiple input modes, including speech, typed text, and image-based inputs.

The core functionality is implemented in the application layer, which includes the Auto-Assist module, OCR module, speech processing modules, gamification engine, and dashboard system. The Auto-Assist module continuously monitors the learner's reading using real-time speech input. Speech is captured using the Web Speech API and analysed to detect pauses and mispronunciations. A pause threshold of 3 seconds is used to identify reading hesitation.

Mispronunciation detection is performed using normalized Levenshtein distance, where the spoken word is compared with the expected word. If the similarity score exceeds a defined threshold, the system triggers Text-to-Speech (TTS) assistance to provide correct pronunciation. This assistance is non-intrusive and occurs only when necessary to maintain reading flow.

The OCR module utilizes Google Cloud Vision API to extract text from both printed and handwritten inputs, enabling multimodal learning. The gamification engine includes interactive activities such as spelling and word-based games to improve engagement and reinforce learning.

The backend is implemented using Firebase services. Firebase Authentication manages secure, role-based access for students, parents, and teachers. Firestore database stores session data, including reading accuracy, timestamps, and progress metrics. This data is used to generate dashboards that provide insights into student performance and improvement trends.

During system operation, the user selects an activity, and the system processes input in real time. Events such as correct readings, assisted words, and pauses are logged and analysed. This continuous feedback loop enables personalized learning and performance tracking.

Figure 1: Field Study at Association for People with Disability (APD), Bengaluru

Figure 2: Field Study at Association for People with Disability (APD), Bengaluru

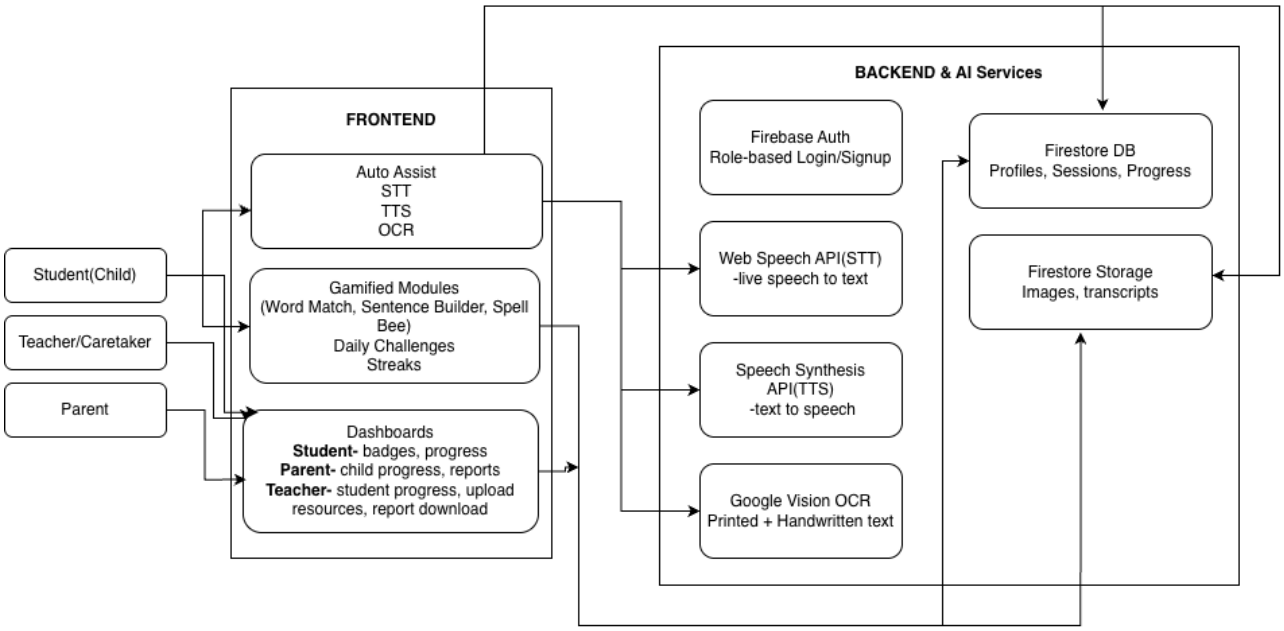

Figure 3: System Architecture of DyslexiAid

Results and Conclusions:

1. The DyslexiAid system was evaluated through controlled testing and a real-world pilot study to validate its core functionalities. In controlled testing, pronunciation detection using normalized Levenshtein distance ($\tau = 0.6$) achieved an accuracy of 70–80%, while the pause detection mechanism (3-second threshold) achieved 100% accuracy in identifying reading delays and triggering assistance. Overall system performance recorded to be ~85%.
2. The pilot study involved five users across several reading sessions, with over 500 words analysed. An average improvement of approximately 18% in reading accuracy was recorded across users, indicating the effectiveness of continuous real-time assistance.
3. Overall, the results confirm that DyslexiAid effectively detects reading difficulties and provides timely assistance, leading to measurable improvement in reading fluency. The integration of real-time feedback, multimodal input, and progress tracking makes the system a practical solution for supporting dyslexic learners.

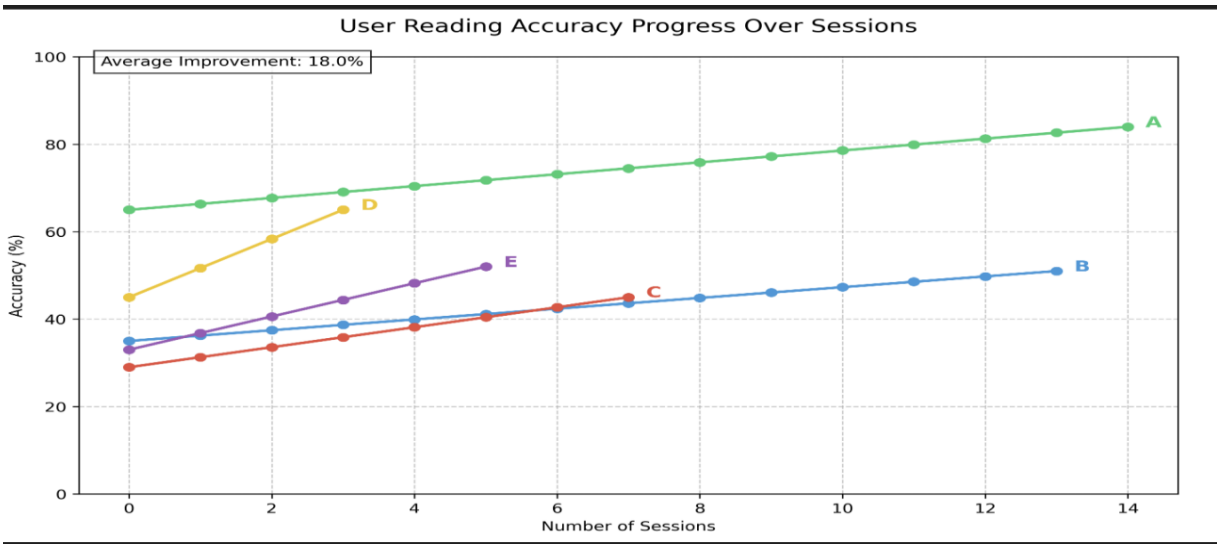

Figure 4: Progressive improvement in reading accuracy across users.

Project Outcome & Industry Relevance:

1. The project contributes to the field of assistive technology by addressing key limitations in existing systems, particularly the lack of real-time struggle detection and personalized feedback. The inclusion of progress tracking dashboards enables data-driven intervention by teachers and parents, enhancing the overall learning ecosystem.
2. In real-world applications, the platform can be deployed in schools, learning centers, and special education institutions to support students with dyslexia. It can also be extended for use in ed-tech platforms and inclusive education initiatives, making quality learning support more accessible and affordable.

Working Model vs Simulation/Study:

1. The project involves the development of a fully functional working model in the form of a Progressive Web Application (PWA). The system supports real-time reading assistance using live speech input, OCR-based text extraction, and interactive learning modules.
2. It is not a simulation or theoretical study, as all core features including Auto-Assist, speech processing, and dashboard analytics have been implemented and tested in real-time scenarios.

Project Outcomes and Learnings:

1. The project resulted in the successful development of an AI-powered assistive learning platform capable of detecting reading difficulties and providing real-time support. Key outcomes include the implementation of pause detection, mispronunciation analysis, and multimodal input handling within a single system.
2. Through this project, valuable insights were gained in integrating AI technologies into real-world applications, handling speech processing challenges, and designing user-centric interfaces for accessibility. The development process also enhanced skills in full-stack development, system design, and data-driven analysis, contributing to both technical and practical learning.

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Future Scope:

The future scope of this project includes:

1. Enhancing the Auto-Assist module using advanced AI models to improve pronunciation detection accuracy and handle diverse speech variations.

2. Incorporating adaptive learning mechanisms that dynamically adjust difficulty levels based on individual user performance and reading patterns.
3. Integrating additional input modalities such as eye-tracking or behavioural analysis to improve real-time struggle detection beyond speech input.