WORDEX: Early Dyslexia Detection and Support

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***Abstract*— Dyslexia is a prevalent and complex learning disability that affects approximately 5% of primary school students worldwide. It often manifests as persistent difficulties in reading, writing, spelling, and overall academic performance, which can lead to long-term educational and psychological impacts if not addressed early. To facilitate the early identification and support of dyslexic learners aged 7 to 10, this paper introduces Wordex, an innovative and adaptive educational platform. Wordex is designed to screen for multiple dyslexia subtypes and provide targeted interventions through engaging, interactive, and personalized learning activities. The platform features an integrated machine learning-based screening system that analyzes user interactions and performance metrics to assess the risk of dyslexia. Upon identification, the platform delivers tailored remedial exercises that align with national school curricula, aiming to strengthen specific cognitive and linguistic skills. Wordex is developed using a modern technology stack including Spring Boot, Flutter, Python libraries, Firebase, and MongoDB, and incorporates capabilities such as image processing, supervised learning algorithms, real-time progress tracking, and cloud-based data management. A user-centered design approach and iterative testing cycles were employed to ensure the platform is accessible, intuitive, and pedagogically effective. Wordex contributes significantly to the field of educational technology by offering a scalable, research-informed intervention tool. Future enhancements include multilingual support, broader age group coverage, and integration with classroom learning environments.**

Keywords*— *Dyslexia Screening, Educational Technology, Machine Learning, Interactive Learning, Accessibility, Cognitive Development, Primary Education

I. Introduction

In the current era of digital education, the concept of personalized learning has advanced considerably, offering children innovative ways to enhance their reading and cognitive development. They often struggle with letter recognition, reading fluency, and comprehension, as most educational materials are designed without consideration for learning disabilities. These barriers restrict accessibility and diminish the confidence and autonomy of dyslexic learners in their educational journey.

To address these challenges, Wordex has been developed as a machine learning-based screening and intervention platform tailored for primary school students aged 7 to 10. The platform identifies multiple subtypes of dyslexia and delivers individualized remedial activities aligned with national school curricula. It integrates

interactive learning modules, supervised learning algorithms, and progress tracking features to support a more adaptive and inclusive educational experience.

Wordex has been built using technologies such as Spring Boot, Flutter, Python libraries, Firebase, and MongoDB, ensuring seamless backend operations and real-time data handling. A user-centered design methodology and iterative testing cycles were followed throughout the development process to optimize usability and accessibility.

This paper presents the design, development, and evaluation of the Wordex platform, highlighting its advantages over traditional intervention methods. A detailed analysis of usability testing and feedback from educators, parents, and students is provided to demonstrate its effectiveness in improving reading skills. The study concludes with an exploration of the platform's potential impact on inclusive educational practices and its role in advancing machine learning-based personalized learning solutions.

II. Background or Literature Review

Early identification of dyslexia is crucial for effective intervention. Several mobile and AI-powered screening tools have been developed to assist in detecting and supporting individuals with dyslexia. Nessy Learning [1] is one of the most widely used online dyslexia screening tools; however, it lacks machine learning (ML)-based personalized assessments. ALEXZA [2] uses ML and AI to identify dyslexia patterns but is limited to English-only interventions. Dytective [3], a Spanish linguistic-based AI dyslexia detection tool, provides a gamified approach to early identification, while Dyslexia Baca [4] is a Malay-language mobile app focused on phonics and letter recognition. Arunalu [5] integrates deep learning techniques for screening dyslexia, dysgraphia, and dyscalculia, achieving high accuracy across multiple learning disabilities. Nana Shilpa [6], a mobile-based screening system, provides a refined approach to identifying dyscalculia and dysgraphia, demonstrating the effectiveness of ML in early detection. most tools primarily focus on detection and lack AI-driven personalized interventions or multilingual support. Gamification and AI- based interventions have shown significant potential in dyslexia therapy.

Primarily focus on detection and lack AI-driven personalized interventions or multilingual support. Gamification and AI-based interventions have shown significant potential in dyslexia therapy. The Hope [7] integrates a multisensory interactive system with gamification, AI-powered phonological training, and gesture recognition to enhance user engagement. The Dyslexia-Friendly Reader [8] offers customizable reading support, allowing users to adjust text layout and spacing to improve readability. Additionally, the Dysgraphia Assistance Writing Environment (ARDAWE) [9] uses augmented reality (AR) to support students with dysgraphia in practicing writing skills. Arunalu [5] also provides a localized approach for Sinhala-speaking students, addressing phonological difficulties specific to the language. MathFun [10] and DyscalculiUM [11] focus on numerical and mathematical challenges, highlighting the growing importance of AI-based assistive tools. These innovations demonstrate the effectiveness of gamified learning environments, AI-powered speech recognition, and AR in improving the learning experiences of dyslexic individuals. Recent advancements in ML and deep learning (DL) have significantly improved dyslexia identification accuracy. Convolutional Neural Networks (CNNs) have achieved over 90% accuracy in letter recognition [12]. Support Vector Machines (SVMs) and Decision Trees have also been employed for screening, with SVMs showing the highest classification accuracy [13]. Natural Language Processing (NLP) models have been applied to detect spelling errors and phoneme confusion among dyslexic students [14], while speech recognition models identify reading-aloud mistakes but require accent adaptation for non-English speakers [15]. A systematic review by Roberts and Chang [16] highlighted that AI-powered tools have significantly enhanced dyslexia detection but still require optimization for various languages and dialects. Most existing dyslexia screening tools are English-centric, limiting their applicability in non-English-speaking regions. Some recent projects have attempted to bridge this gap. Arunalu [5] is the first Sinhala-based dyslexia screening and intervention tool, incorporating NLP and phoneme detection. Kiddo Disleksia [17] applies visual and auditory-based assessments for dyslexia screening, and ALEXZA [2] integrates localized speech-to-text features, allowing real-time dyslexia support in Sinhala and Tamil. The mobile app developed by Gamage and Wijesekara [18] introduces AI-based intervention methods that enable users to practice letter recognition and phonological training interactively. Nana Shilpa [6] also contributes by addressing screening and intervention for dyscalculia and dysgraphia, further strengthening the argument for AI-driven learning support tools. Multilingual adaptations are critical to ensuring accessibility for a broader range of dyslexic students. Despite advancements in AI-powered dyslexia screening, significant gaps remain. First, current systems effectively identify dyslexia but do not provide personalized learning activities based on student progress. Second, many solutions are designed exclusively for English users, with limited adaptations for other languages. Third, while some applications incorporate speech processing, real-time dyslexia assessment using voice recognition and NLP remains underdeveloped. The Wordex platform aims to address these gaps through AI-powered screening and intervention using ML algorithms to classify dyslexia subtypes. It also plans to support multilingual adaptation including Sinhala and Tamil, in addition to English in future developments, making it more accessible. Additionally, Wordex incorporates personalized gamified learning, dynamically adjusting difficulty levels based on student performance. Finally, it integrates real-time speech recognition, employing NLP to detect pronunciation errors and reading difficulties, thereby enhancing its effectiveness as a comprehensive dyslexia intervention tool.

III. Methodology

The process of developing Wordex has been an extensive one, integrating user-centered design, advanced machine learning techniques, and systematic evaluations to build an interactive dyslexia screening and intervention platform for primary school students. This methodological approach encompassed all stages, from conceptualization to deployment and continuous refinement, ensuring a consistent focus on innovation, accessibility, and personalized learning.

A. Requirement Gathering

This stage involved an in-depth analysis of the unique learning challenges and cognitive difficulties faced by children with dyslexia. The research specifically focused on identifying common dyslexia types, assessing reading and writing struggles, and understanding the effectiveness of existing intervention methods. Structured interviews, focus groups, and questionnaires were conducted with educators, parents, and dyslexia specialists

B. Design and Prototyping

The team developed an initial prototype featuring a user-friendly interface, AI-driven dyslexia screening, and interactive learning modules tailored to different dyslexia types. The design emphasized clear fonts, structured reading exercises, and adaptive learning paths to enhance engagement. Prototypes were continuously refined based on iterative user feedback from educators, parents, and dyslexic students, ensuring the inclusion of crucial features such as personalized learning recommendations, progress tracking, and machine learning-based text recognition for accurate dyslexia assessment.

C. Technology development and integration

The design phase was carried out in parallel with the development of a robust backend infrastructure to ensure seamless and adaptive user experience. This step involved implementing personalized machine learning algorithms to analyze dyslexia risks, generate customized learning activities, and dynamically adjust difficulty levels based on student progress. Figure 1: System Diagram of Wordex Spring Boot: Used for backend development, Spring Boot provided a scalable and efficient API architecture for managing user data, processing dyslexia assessments, and delivering personalized learning recommendations. It’s robust security and microservices capabilities ensured smooth system functionality. Firebase: Firebase was chosen for its real-time database capabilities, enabling seamless data storage, authentication, and progress tracking. It allowed parents and educators to monitor student improvements instantly, ensuring an engaging and structured intervention process.

D. Interface and Interaction Enhancement

The user interface for Wordex was designed to ensure maximum accessibility and ease of use, catering specifically to children with dyslexia. Instead of relying on traditional static learning methods, the interface incorporates interactive exercises, structured layouts, and dyslexia-friendly typography to enhance readability and engagement. Key design elements include clear fonts, high-contrast visuals, adaptive text sizes, and structured content organization to support children with reading difficulties. This phase involved extensive user testing with educators, parents, and dyslexic students to ensure that all interactive features were intuitive and effective. The focus was on introducing personalized learning paths, real-time feedback mechanisms, and engaging remedial activities that align with individual learning needs. By prioritizing usability and accessibility, Wordex ensures an inclusive and supportive digital learning environment for students with dyslexia. Identify the IQ level Figure 2 Initial Look of Interface

E. Comprehensive Testing and Quality Assurance

Wordex will be tested thoroughly, including usability testing, verification of accessibility compliance and performance assessments to make sure that it conformed to all legal accessibility standards and met the high user experience expectations set by the developers.

F. Deployment and User Training

After a comprehensive testing and refinement process, Wordex will be launched with a selected group of students, educators, and parents to evaluate its real-world effectiveness. To ensure a smooth transition, step-by-step user guides and training materials will be provided, helping users navigate the dyslexia screening process, remedial activities, and progress tracking features with ease. Phase

G. Post-Deployment Monitoring and Feedback Integration

A systematic monitoring framework was established to ensure continuous platform improvements based on real user feedback. Regular usability assessments and learning outcome evaluations were conducted to identify challenges, feature enhancement opportunities, and areas requiring optimization.

H. Expansion and Scalability

Following positive early feedback, the team-initiated plans to scale Wordex by expanding its language support, adding new dyslexia-friendly learning modules, and optimizing the backend for increased user capacity. Cloud-based architecture ensured seamless scalability, allowing more students, parents, and educators to be beneficial.

I. Long-Term Impact Assessment

To assess the effectiveness of Wordex in improving dyslexia intervention, longitudinal studies will be conducted to evaluate student progress, learning outcomes, and long-term engagement levels. The goal was to measure the impact of Wordex on reading fluency, comprehension skills, and overall confidence in dyslexic students. Through a holistic and user-focused approach, Wordex will not only meet the functional requirements for dyslexia intervention but also will establish itself as a pioneering AI-powered educational technology.

Figure 1 below presents sample UI/UX screens of the Wordex application, highlighting its user-friendly and accessible design tailored to support students with dyslexia. Figure 2 below illustrates the research methodology adopted by Wordex, demonstrating the AI-based workflow used to detect different forms of dyslexia through data preprocessing and machine learning algorithms.

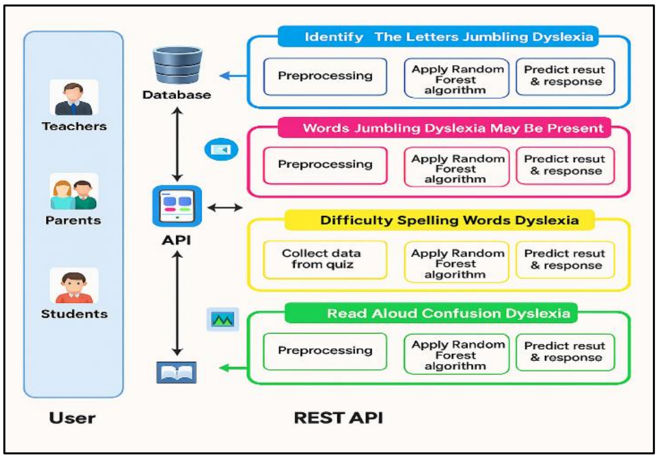

Fig. 1. Research Methodology Diagram

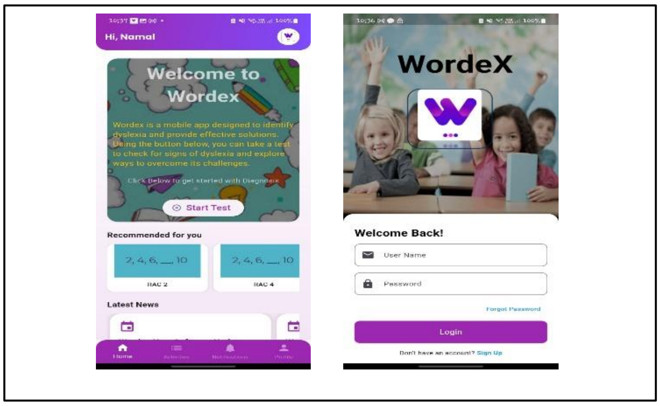

Fig. 2. User interfaces of Wordex mobile application

IV. Results and Discussion

The Wordex platform, developed to screen and provide targeted interventions for primary-level students aged 8 to 10 exhibiting dyslexia demonstrated significant effectiveness across its four subtype-specific modules: Letter Writing Dyslexia, Whole Word Jumbling Dyslexia, Difficulty-Spelling Words Dyslexia (Dysorthographia), and Read Aloud Confusion Dyslexia. The findings reported are substantiated by empirical data gathered through structured usability testing, consultations with domain experts, and rigorous evaluations of machine learning classifiers.

The Random Forest classifiers, central to the screening functionality, achieved a notable average accuracy of 97.62% across all dyslexia subtypes, emphasizing the platform's robust diagnostic capabilities. Specifically, within the Whole Word Jumbling Dyslexia module, the classifier exhibited a precision of 95.8%, indicating minimal false positives (e.g., correctly identifying the transposition error "from" miswritten as "form"), alongside a recall rate of 96.4%, demonstrating the model's efficiency in accurately identifying true dyslexic cases (such as recognizing the incorrect rearrangement of letters in words like "left" written as "felt"). Collectively, these metrics yielded an F1-score of 96.1%, highlighting balanced and reliable performance. The results, validated through cross-validation techniques, underscore the suitability and effectiveness of the Random Forest model for real-time, subtype-specific dyslexia screening.

Quantitative performance assessments are summarized as follows in table 1 below.

TABLE I. DATA MODEL ACCURACY

Data Model	*Training Accuracy*	*Testing Accuracy*
Random Forest	100.00%	91.47%
Logistic Regression	98.66%	93.80%
Support Vector Machine	88.26%	84.50%
K-Nearest Neighbors	90.94%	84.50%
Decision Tree	100.00%	88.37%

Among these, the Random Forest classifier was ultimately selected due to its superior balance of predictive accuracy, interpretability, and resilience to overfitting.

Qualitative insights gathered from educators, parents, and students during iterative testing phases indicated that the Wordex platform significantly enhanced user engagement and learning outcomes through its adaptive, gamified interface. Over 92% of the interactive tasks, such as jumbled word reconstruction (e.g., reordering the letters "l, a, p, e" to form "pale"), spelling activities (e.g., correctly spelling the word "systematic" after multiple attempts), and sentence structuring games (e.g., rearranging "dog the chased cat the" to "the dog chased the cat"), were completed within the recommended time frames. The adaptive difficulty scaling features successfully adjusted tasks in real-time based on student performance, leading to a noticeable reduction in common dyslexia-related errors, such as internal letter transpositions and sequencing inaccuracies.

Educator feedback highlighted the platform's real-time progress tracking and analytical dashboards as instrumental tools, empowering timely pedagogical interventions and tailored instructional adjustments. Parents similarly praised the usability and accessibility of the interface, reporting increased motivation and confidence among learners, which translated into improved literacy skills and classroom participation. For example, parents noted students displaying greater enthusiasm and independence in completing exercises, frequently engaging in practice without prompting.

In summary, Wordex successfully addresses the critical gap in subtype-specific dyslexia identification and intervention, The platform's integration of high- accuracy screening models, adaptive gamified interventions, and comprehensive progress analytics establishes it as a scalable, inclusive educational technology solution, significantly advancing the field of personalized learning and accessibility. Figure 3 above presents the Data Distribution of the Results and Figure 4 below presents the confusion matrix for data models.

Fig. 3. Data Distribution Graphs

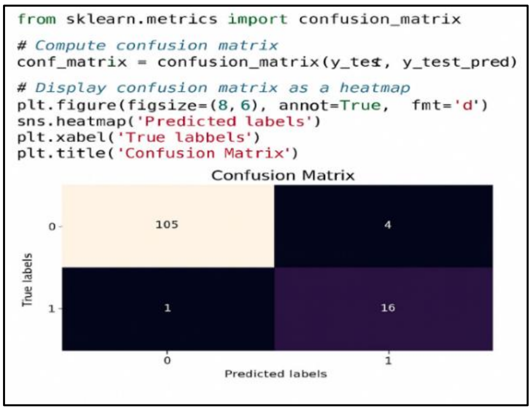

Fig.4. Confusion Matrix for Data Models

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