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Design and development of AI powered platform for inclusive learning of Differently Abled Students

Anushka Alhat[1], Priyal Sethi[2], Rajesh Holmukhe[3]

[1,2,3]Bharati Vidyapeeth Deemed to be University College of Engineering, Pune

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Abstract

The use of technology in the classroom has greatly enhanced learning opportunities in recent years. However, it can be difficult for students with disabilities to access inclusive educational resources, especially if they have visual or hearing impairments. In order to assist students who are visually and hearing impaired, this paper suggests an AI-powered e-learning platform. Screen reader compatibility, text-to-speech, sign language video content, voice-based navigation, and an intelligent automated doubt solving assistant are just a few of the accessibility features included in the system. The platform guarantees equitable access to education, promotes independent learning, and improves knowledge retention through the use of artificial intelligence and user-centric design. User testing and feedback from students with disabilities are used to assess the system's efficacy, showing increased engagement and academic achievement.

Keywords: E-Learning; Accessibility; Visual Impairment; Hearing Impairment; Inclusive Education; Assistive Technology; Artificial Intelligence; Automated Doubt Resolution; Special Education; Screen Reader; Sign Language Integration.

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Introduction

Access to inclusive and high-quality learning resources can be extremely difficult for students with visual and hearing impairments, education is a fundamental right. These students' special needs are often not met by traditional e-learning platforms, which limits their engagement, comprehension, and academic advancement. The Inclusive E-Learning Platform for Students with, a web-based application created to empower visually and hearing-impaired learners through accessible, interactive, and AI-assisted education, is the project's solution to these problems. In order to address these audio descriptions, the system includes screen reader compatibility, sign language-integrated video content, authorities, and victims, as well as customizable interfaces to accommodate a range of learning needs. In order to solve these problems, this project suggests a web-based tool called Tiled, an inclusive learning application for students with disabilities. It is intended to empower students with visual and hearing impairments through accessible, interactive, and AI-assisted instruction.

Objective

The primary goal of the Inclusive E-Learning Platform for Students with Disabilities is to establish a digital learning environment that guarantees visually and hearing-impaired students equal access to high-quality education. Through accessible interfaces, AI-based doubt-solving, and inclusive content design, this system seeks to dismantle conventional barriers in online education. It promotes an interesting, encouraging, and customized learning experience catered to the particular requirements of learners with disabilities by utilizing contemporary web technologies.

- Providing learning resources: Educational content which is optimized for screen readers, sign language videos, and audio-described materials. The lessons are designed in such a way that it is compatible with assistive technologies and caters to the demand of different sensory needs. The learners can access their learning content without requiring external assistance.
- Personalizing the learning experience: The platform provides role-based access for the users, such as students, teachers and volunteers. Each user is provided a personalized dashboard according to their role, where students can track their progress and view their schedule and learning resources. Teachers can upload learning materials in an accessible format and monitor the student's response.
- Real time interaction with the instructor: This system employs technologies like Socket.IO to provide real-time interaction between the students and instructors. This is beneficial for the students to solve their doubts, to ask queries and even to have live sessions.

Literature Review

The literature on inclusive learning application for differently abled students is a growing area of research, and mobile technologies and assistive tools are increasingly being used to increase access and inclusion for students with visual, hearing, motor and cognitive impairments. Prior literature reviews from the early 2010s mainly focused on the use of basic mobile devices including smartphones and tablets. These reviews showed that mobile devices are inexpensive alternatives to expensive traditional assistive devices, and are beneficial for users in terms of independence, communication, and participation in education (Fernández-Batanero et al., 2022; Ismaili & Ibrahimi, 2017). Systematic reviews indicate that assistive technologies (AT), including mobile app-based solutions, facilitate inclusion and accessibility by increasing academic engagement, independence, social skills, motivation, and attention for students with disabilities. However, barriers to their implementation exist including teacher training and awareness, lack of accessibility, and technological challenges (Fernández-Batanero et al., 2022 in Educational Technology Research and Development). Mobile Applications in Special and Inclusive Education: A Systematic Review of the Past Decade. Special and inclusive education has greatly benefited from mobile applications, assisting students in personalized and multimodal learning (Zaharudin et al., 2024; Bell & Vander Molen, 2020). These applications have proven effective in aiding communication, daily living, and academic tasks for students with learning disabilities, intellectual disabilities, dyslexia, and sensory impairments (Zaharudin et al., 2024). Features such as text-to-speech (TTS), speech-to-text, captions, and adaptive interfaces support visually and hearing-impaired learners, while gamified modules and progress trackers assist those with cognitive and motor challenges (e.g., reviews on TTS impact for reading comprehension in students with learning disabilities). Recent studies (2020–2025) emphasize the integration of AI for adaptive content recommendation, real-time personalization, and dynamic difficulty adjustment, aligning with Universal Design for Learning (UDL) principles to reduce barriers and promote equity (e.g., immersive technologies and generative AI for personalized support; systematic reviews on AR, mobile devices, and tablets for inclusive education).

Research Gap

Lack of customizing e-learning platforms for visually and hearing- impaired learners. Present e-learning platforms are not customized for disabled students. Lessons are available on text and video with no real-time doubt clearing facility for disabled students, hence making them need somebody to clear their doubts, leading to delayed learning.

- Lack of inclusive communication tools: Conventional e-learning systems lack real- time doubt clearing facilities for disabled students. They lack accessible chatbots, voice assistants or sign-language support. As a result, students have to wait for teachers or parents to clear their doubts, causing learning delays.
- Inaccessible user interface design: Many e-learning platforms do not adhere to accessibility standards. Visually impaired students can't use screen readers and hearing-impaired students can't access subtitles or sign-language options, which reduces usability.
- Inability to personalize progress tracking: Conventional learning platforms provide generic progress tracking tools that don't account for the pace or challenges of disabled learners. Educators lack detailed insights into learning gaps or accommodations needed for these students.

Methodologies

The first stage involves collecting the educational needs of visually and hearing impaired users through surveys/interviews with special educators. From the data collected, learning materials are selected from databases and categorized based on subject, difficulty level, and accessibility needs. This can include audio lessons for visually impaired users, videos with sign language for hearing-impaired users, screen reader-friendly text-based content, and quizzes. Data is stored in a structured format in MongoDB.

- Accessibility Features and UI Development: Accessibility and ease of use are prioritized. Visually impaired users can access text-based content and navigate with voice commands or a text-to- speech engine. Hearing-impaired users can access videos with sign language and subtitles. User interface (UI) and user experience (UX) is developed in React.js with large fonts, high contrast themes, and screen reader-friendly elements (e.g. ARIA attributes).
- Intelligent Doubt-Solving Module: An AI-driven Chabot is integrated into the platform using NLP (natural language processing) models and speech-to-text/text-to-speech technology. This allows students to ask their doubts/questions using voice or text. The chatbot can provide contextual answers using a pre-existing knowledge base or via machine learning approaches. This will allow students to quires doubts independently without the need for constant input from humans.
- Analytics and Feedback System: Real-time analytics is integrated into the system to track user progress and engagement. Users can also provide feedback on accessibility or content issues. Admins and educators can review analytics dashboards and use this information to improve the platform.
- Deployment and Integration: The platform is deployed with responsive design to ensure accessibility across devices, including mobile. Lightweight architecture ensures efficient performance even on lower-end devices. Offline access to essential content is integrated to support usage in low-connectivity areas.

Proposed System

Screen shot of Dyslexia Learning Platform interface. Image displays Text-to-Speech and Image-to- Text tools for helping students with dyslexia and other related learning disabilities.

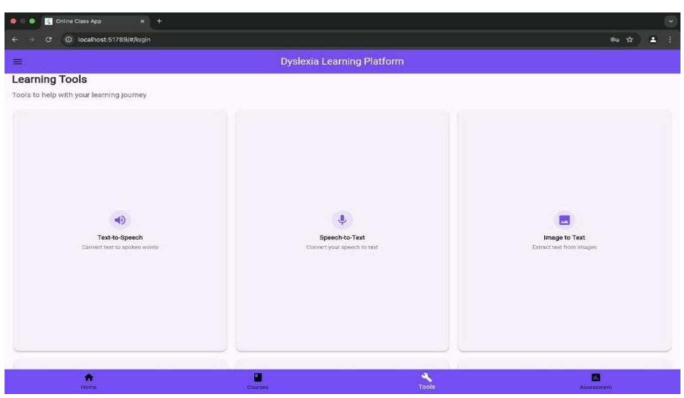

Fig. 1. *Accessibility Dashboard of the AI-Based Learning System for Students with Special Needs*

Text-to Speech (TTS) is a technology that converts written text into spoken words. Itanalyzesthe text and converts it into phonetic sounds, which are then generated into audio using pre-recorded voice samples oral text-to-speech engine. Speech-to-Text (STT) is a technology that converts spoken words into written text. It captures the sound waves from the speaker's voice and processes the speech to recognize and transcribe the spoken language into text. Both TTS and STT are widely used in various applications, such as accessibility tools, virtual assistants, and transcription services.

- Text-to-Speech: Text Analysis: The system analyzes the input text to understand its structure, punctuation, and context. Phonetic Conversion: The text is converted into phonetic representations, which are the sounds that make up words.

- Speech-to Text: Sound Wave Capture: The system captures the sound waves from the speaker's voice through a microphone. Signal Processing: The captured sound is processed to identify different sounds, frequencies, and patterns in the speech.
- Speech Recognition: The system uses machine learning algorithms and a large database of words and sounds to recognize the speech. This can involve various models like Hidden Markov Models (HMMs) or Deep Neural Networks (DNNs).

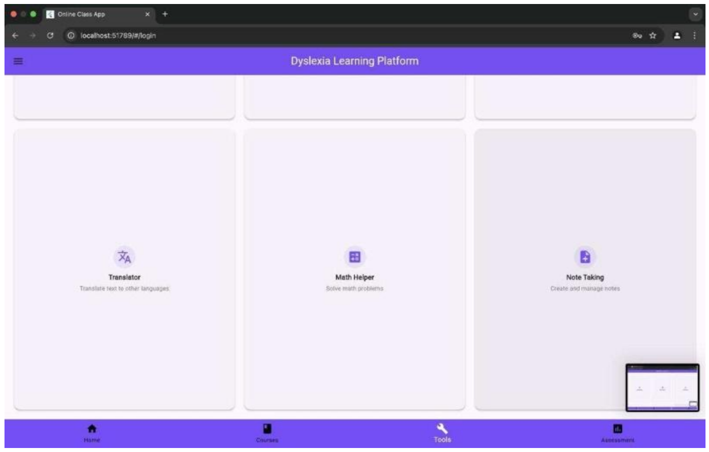

Fig. 2. *Advanced Accessibility Features of the Dyslexia Learning Platform*

This tool translates text into other languages. For students with dyslexia, who may have difficulty decoding unfamiliar or complex words/scripts, translation may help simplify content by translating challenging English (or primary language) text into a more familiar language. This can improve comprehension, vocabulary building, and access to multilingual content (particularly helpful for diverse populations such as in India, with many languages). The tool would reduce frustration when reading, increase engagement with curriculum content, and support bilingual students who may be able to process information more easily in theirmothertongue.

Example: "What's up?" → "Ky haal hai?"; This approach would result in a natural-sounding and contextually relevant output.

To improve recognition performance, noise reduction and speech normalization techniques are employed, particularly useful in a casual conversation context.

Math Helper This tool helps students with math problems, providing step-by-step solutions, visual representations, or easier ways to input problems. This would be particularly useful for students with dyscalculia (a math-specific learning difficulty that often co-exists with dyslexia) or students who struggle with number alignment, calculations, or word problems due to reading/writing challenges. The tool can help organize problems (e.g., on digital graph paper), reduce handwriting errors, and enhance confidence with clear explanations or visual representations. Benefits include improved numeracy skills, reduced math anxiety, and better performance on math-related assignments. Similar apps that help students with math include Modmath (digital graph paper and keypad for dyslexia/dysgraphia),

Photomath (scan-and-solve with step-by-step explanations), or MathTalk (voice-based math problem input).

The feature allows the user to take notes, organize and edit them in a manner that is user friendly, whether using a keyboard, voice, highlighting and/or formatting. Learners with dyslexia are often challenged by spelling, handwriting speed, organization and retaining important lecture information when taken notes. This technology alleviates some of the cognitive load by enabling the user to quickly capture thoughts without being perfect at writing. This feature also allows for better reviewing of lecture material with searchable, editable notes, audio sync (if integrated), or organized in a visual format.

Fig. 3. *Interactive Learning Assessments for Monitoring Student Progress and Skill Development*

Chapter Quizzes

Encouraging learning through the Assessments section

The Assessments section in the dyslexia learning platform prototype plays a crucial role in encouraging learning and building confidence in students with dyslexia with its collection of completed quizzes and an unfinished quiz, as well as practice exercises. Each quiz is associated with a chapter, and each has an assessment score, green checkmark or "start" button to provide immediate feedback to the learner, with checkmarks indicating completion and the purple "start" button indicating that the learner hasn't yet finished the quiz. The completed quizzes on the example page include "Chapter 1: Reading Basics" (8/10), "Chapter 2: Vocabulary Building" (10/12), and "Chapter 3: Reading Fluency" (unfinished). Each of these quizzes are designed to test the student's knowledge of a particular chapter, and their learning progress as they move through the program. The practice exercises are centered on improving reading and language skills that are typically difficult for students with dyslexia, such as mapping sounds to letters and recognizing single words, and they follow a similar format with a name, an assessment score, and a green checkmark upon completion. The practice exercises include "Phonics Practice" (7/8), "Word Recognition Drill" (13/15), and "Sentence Building Practice" (unfinished). These exercises are designed to help students build mastery over specific reading and language skills, and their completion status and scores provide immediate feedback to encourage and motivate the learner to continue practicing and improving their abilities.

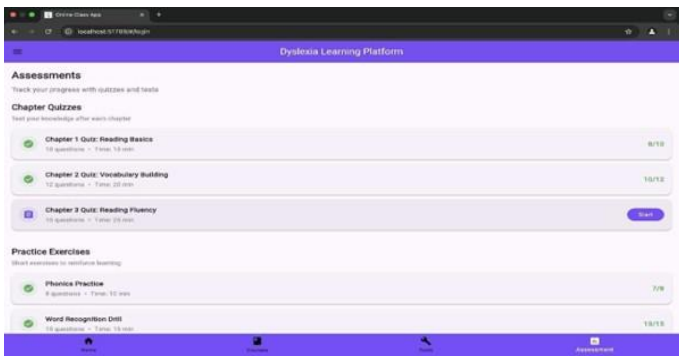

Fig. 4. *Assessments - Practice Exercises, Progress Tests.*

This screen shows the lower part of the Assessments section of the Dyslexia Learning Platform prototype. The Practice Exercises subsection is relevant to students' reinforcement of foundational skills and includes a short drill (Phonics Practice, 8 questions, 10 minutes, 7/8 scored with a green check mark) and a short drill (Word Recognition Drill, 15 questions, 15 minutes, 13/15 scoredwith a green check mark).

Pending activities are indicated by "Start" buttons in purple (Reading Comprehension Practice, 10 questions, 20 minutes, and Spelling Practice, 12 questions, 15 minutes). The Progress Tests subsection is relevant to the assessment of students' longer term improvement across all foundational skills and includes a completed (Midterm Assessment, 30 questions, 45 minutes, 24/30 scored with a green check mark) and a pending (Final Assessment, 40 questions, 60 minutes) test.

Code

1. Text-to-Speech Algorithm

This code shows how the application processes text and converts it to speech, which is crucial for helping dyslexic users:

```
dartFuture<void> speak(String text) async { if (text.isNotEmpty) {
await widget.flutterTts.setLanguage("en-US");
await widget.flutterTts.setSpeechRate(0.5); // Slower rate for better comprehension await widget.flutterTts.setVolume(1.0);
await widget.flutterTts.setPitch(1.0); await widget.flutterTts.speak(text);
}
}
```

2. Speech-to-Text Algorithm

This algorithm handles converting spoken words to text, providing an alternative input method: dartvoidstartListening() async {

```
if (!isListening) {
bool available = await widget.speech.initialize(); if (available) {
setState(() =>isListening = true); widget.speech.listen(
onResult: (result) { setState(() {
recognizedText = result.recognizedWords;
});
```

```
},
listenFor: Duration(seconds: 30),
pauseFor: Duration(seconds: 5), localeId: 'en_US',
);
} else {
print("Speech recognition not available");
}
}
}
void stopListening() { if (isListening) { widget.speech.stop();
setState(() =>isListening = false);
}
}
```

3. Quiz Assessment Algorithm

This algorithm processes user answers, provides feedback, and calculates scores: dartElevatedButton(

```
onPressed: question['selectedIndex'] == -1
? null
: () {
if (_currentQuestionIndex< _questions.length - 1) { setState(() {
_currentQuestionIndex++;
});
} else { setState(() {
_quizCompleted = true;
});
}
},
child: Text(_currentQuestionIndex< _questions.length - 1 ? 'Next' : 'Finish'), style: ElevatedButton.styleFrom(
backgroundColor: Colors.deepPurpleAccent, foregroundColor: Colors.white, disabledBackgroundColor: Colors.grey,
),
)
```

4. Video Thumbnail Generation Algorithm

This algorithm generates thumbnails from video content for the learning modules: dartFuture<Uint8List?> _getVideoThumbnail(String videoPath) async {

```
final uint8list = await VideoThumbnail.thumbnailData( video: videoPath,
imageFormat: ImageFormat.JPEG, maxWidth: 280,
quality: 25,
);
return uint8list;
}
```

5. Progress Tracking Algorithm

This algorithm visualizes learning progress to help motivate users: dartWidget _buildProgressSection() {

```
return Card( elevation: 5,
shape: RoundedRectangleBorder(borderRadius: BorderRadius.circular(15)), child: Padding(
padding: const EdgeInsets.all(16.0), child: Column(
crossAxisAlignment: CrossAxisAlignment.start, children: [
Row(
mainAxisAlignment: MainAxisAlignment.spaceBetween, children: [
Text(
'Your Progress',
style: TextStyle(fontSize: 18, fontWeight: FontWeight.bold),
),
Text(
'45% Complete',
```

```
style: TextStyle(fontSize: 16, color: Colors.deepPurpleAccent),
),
],
),
SizedBox(height: 15), ClipRRect(
borderRadius: BorderRadius.circular(10), child: LinearProgressIndicator(
value: 0.45,
minHeight: 12,
backgroundColor: Colors.grey[300],
valueColor: AlwaysStoppedAnimation<Color>(Colors.deepPurpleAccent),
),
),
SizedBox(height: 15), Row(
mainAxisAlignment: MainAxisAlignment.spaceBetween, children: [
_buildProgressStat('Lessons', '9/20'),
_buildProgressStat('Exercises', '15/30'),
_buildProgressStat('Quizzes', '3/7'),
],
),
],
),
),
);
}
```

6. Navigation and State Management

This code shows how the application handles navigation between different sections: dartbottomNavigationBar: BottomNavigationBar(

```
currentIndex: _selectedIndex, onTap: (index) {
setState(() {
_selectedIndex = index;
});
},
backgroundColor: Colors.deepPurpleAccent, selectedItemColor: Colors.white, unselectedItemColor: Colors.black,
type: BottomNavigationBarType.fixed, items: [
BottomNavigationBarItem( icon: Icon(Icons.home), label: 'Home',
),
BottomNavigationBarItem( icon: Icon(Icons.book), label: 'Courses',
),
BottomNavigationBarItem( icon: Icon(Icons.build), label: 'Tools',
),
BottomNavigationBarItem(
icon: Icon(Icons.assessment), label: 'Assessment',
),
],
)
```

7. Video Player Initialization

This algorithm sets up the customized video player for lessons: dartvoidinitializeVideo() {

```
_videoPlayerController = VideoPlayerController.asset(widget.videoAsset)
..initialize().then((_) {
setState(() {});
});
_chewieController = ChewieController( videoPlayerController: _videoPlayerController, autoPlay: true,
looping: false, aspectRatio: 16 / 9, showControls: true,
```

```
    materialProgressColors: ChewieProgressColors( playedColor: Colors.deepPurpleAccent, handleColor: Colors.deepPurpleAccent,
backgroundColor: Colors.grey[300]!, bufferedColor: Colors.grey[200]!,
    ),
    );
    }
```

These code snippets represent the core algorithmic components of the Dyslexia Learning Platform, focusing on the assistive technology features, educational content delivery, and user interaction mechanisms that make the application accessible and effective for users with dyslexia.

Significance of the Project and Future scope

Significance of the Project

- The project will enable differently abled students to have equal learning opportunities by providing accessible digital learning tools.
- The project will help overcome major barriers faced by differently abled students in traditional classrooms through features such as audio lessons, text-to-speech conversion, sign language support, and simplified user interfaces.
- The project will promote inclusive education by ensuring that every child can learn independently and progress at their own pace.
- The project will encourage active participation of parents and teachers through progress tracking and performance monitoring features.
- The project is affordable and scalable, making it suitable for adoption by schools, NGOs, and government institutions to support differently abled students.
- The project will promote the use of technology to create a barrier-free, inclusive, and equitable learning environment for differently abled learners.

Future Scope

- AI-Based Personalization: The system can incorporate artificial intelligence to personalize learning content according to each student's abilities, preferences, and difficulty levels.
- Sign Language Recognition: Machine learning-based sign language recognition and translation can be integrated to convert sign gestures into text or audio outputs.
- Haptic Feedback Systems: Future versions may include haptic feedback technology and Braille device integration to enhance accessibility for visually impaired learners.
- Cloud Database Integration: A cloud-based database can be incorporated to enable seamless content updates, secure data storage, and improved accessibility across multiple devices and locations.

Conclusion

Translation tools have been pretty good at dealing with clean and formal speech, but let's be honest, most conversations are not like that. People swear, use slang, drop words, and talk in different ways that are not described in any text book, unless we make one. And that's exactly what we were trying to do with this app.

We are creating a speech to text and text to speech translation system that can understand slang and other slangs that people use in conversations.

It has voice recognition, language processing, and some clear neural models to understand text to speech and speech to text in a very smooth manner. This includes great translations that look and feel very accurate**.**

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