LEXAYUDHA : PERSONALIZED AI-DRIVEN REHABILITATION FOR ADOLESCENTS WITH DYSLEXIA AND DYSCALCULIA

T. Umesha Dilshani Silva

(IT21318320)

BSc (Hons) degree in Information Technology Specializing in Software Engineering

Department of Computer Science & Software Engineering

Sri Lanka Institute of Information Technology
Sri Lanka

April 2025

LEXAYUDHA : PERSONALIZED AI-DRIVEN REHABILITATION FOR ADOLESCENTS WITH DYSLEXIA AND DYSCALCULIA

T. Umesha Dilshani Silva

(IT21318320)

Dissertation submitted in partial fulfillment of the requirements for the Bachelor of Science (Hons) in Information Technology Specializing in Software Engineering

Department of Computer Science & Software Engineering

Sri Lanka Institute of Information Technology
Sri Lanka

April 2025

DECLARATION

I declare that this is my own work, and this dissertation does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Also, I hereby grant to Sri Lanka Institute of Information Technology, the non-exclusive right to reproduce and distribute my dissertation, in whole or in part in print, electronic or other medium. I retain the right to use this content in whole or part in future works (such as articles or books).

Signature: Date: 11.04.2025

The above candidate has carried out research for the bachelor's degree Dissertation under my supervision.

Signature of the supervisor: Date: 2025-04-11

Abstract

Learning disabilities such as dyslexia and dyscalculia affect a significant number of adolescents worldwide, often resulting in difficulties with reading fluency, comprehension, and engagement. Traditional educational tools typically lack the personalization and adaptability required to meet the diverse cognitive and sensory needs of these students. In response to this challenge, LexAyudha has been developed as a personalized, AI-based learning platform aimed at delivering adaptive reading support through innovative technologies.

The platform has its unique Chromatic Variation-Based Teaching Module, which integrates three key components: chromatic variation to reduce visual stress, dynamic sentence generation tailored to each learner's reading level, and a Text-to-Speech (TTS) module that offers real-time pronunciation feedback. Sentences are generated using a fine-tuned BERT model trained on a dataset taken from educational material, while real-time color adjustments are achieved via Chroma.js to support user-specific visual comfort. The TTS functionality is used to evaluate and guide correct pronunciation.

A pilot evaluation was conducted with dyslexic adolescents aged 8–12, using both quantitative assessments and qualitative feedback. Results demonstrated an improvement in reading accuracy, a reduction in visual stress, and a match rate between sentence complexity and individual proficiency. Additionally, the platform received a high average usability rating, indicating high user satisfaction and engagement.

The study concludes that LexAyudha offers a robust and scalable solution for supporting neurodiverse learners by effectively combining AI, and other technologies. Future enhancements such as multilingual support are recommended to further increase the platform's accessibility and impact across diverse educational contexts.

Keywords: *adaptive learning, artificial intelligence, chromatic variation, dyslexia*

Acknowledgement

I am grateful to everyone who helped make this project a reality. First, a sincere thanks to my supervisor, Prof. Samantha Thelijjagoda, my co-supervisor, Dr. Junius Anjana, and our external supervisor, Dr. Asiri Hewamalage. Their guidance, thoughtful feedback, and constant support have meant so much throughout this journey. I have learned a great deal from their mentorship, and this project would not be what it is without them.

I would also like to express my appreciation to Mrs. G. Nadeeka Priyangani Rupasinghe, Principal of R/Raththurugala Vidyalaya, Ratnapura, for her kind support in helping us connect with students for testing and data collection.

I would like to convey my thanks to my teammates for dedication, late-night brainstorms, problem-solving energy, and the shared vision that kept us moving forward. It's been a pleasure building this project together.

Most importantly, I want to thank my family. This project came to life thanks to the collective effort of so many people, and I'm genuinely thankful to each and every one of you.

.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

Abbreviation	Description
AI	Artificial Intelligence
NLP	Natural Language Processing
TTS	Text to Speech

1. INTRODUCTION

Dyslexia is one of the most common learning disabilities affecting adolescents worldwide [1], but still frequently misunderstand the nature of the disability, causing problems when addressing the unique requirements. In the United States alone, more than 32% suffer from learning disabilities and specifically 19% suffer from speech or language impairment (Refer Appendix A, Figure 1) [2]. In Sri Lanka, it has been reported in 2019, that total of 2397 male students and 1140 female students from grade 1 to grade 11 repeaters to have dyslexia (Refer Appendix A, Figure 2) [3]. Characterized by difficulties in reading and writing for dyslexics and trouble in mathematical calculations for those who are affected by dyscalculia, these conditions impact the academic success, social development, and emotional well-being of adolescents [4]. Despite the presence of assistive educational tools, a significant part of current interventions lack real-time personalization that caters to the unique learning requirements of individuals with dyslexia and dyscalculia. Traditional teaching methods often follow a generalized process that fails to accommodate the neurodiverse needs of these learners, leading to frustration, disengagement, and lowered self-esteem.

The advent of artificial intelligence (AI) in education offers a transformative opportunity to address these challenges through personalized learning environments. AI technologies can dynamically analyze a learner's progress, identify difficulties in real time, and adapt educational content accordingly. LexAyudha is one such initiative, offering an AI-driven platform tailored to the rehabilitation of adolescents with dyslexia and dyscalculia. One of the main components of this platform is the Chromatic Variation-Based Teaching module (Refer Appendix B, Figure 1-3), which combines adaptive sentence generation, real-time chromatic modifications, and audio feedback to support reading fluency and comprehension.

By fine-tuning pre-trained language models and incorporating visually optimized text displays, the module provides learners with content that is not only appropriate to address individual readability skills but also visually comfortable. The approach also comprises the features of Text-to-Speech (TTS) technologies that reinforce auditory learning and provide real-time pronunciation feedback. The outcome of each of the components ensures a personalized, engaging, and low-stress learning environment. The following sections provide an in-depth examination of the theoretical foundations, research gap, and innovative objectives that guide the development of this novel platform.

1.1 Background Literature

In recent decades, significant research has explored the relationship between chromatic variation and dyslexia, especially regarding how color modifications can improve reading fluency and comprehension for dyslexic individuals. Visual stress manifesting as distorted or blurred text is a common issue among dyslexic readers, particularly when engaging with traditional black-on-white content. This condition not only obstructs fluency but also negatively affects comprehension and overall engagement.

Studies, such as those by Pinna and Deiana (2018), have shown that specific color combinations, most notably pale-yellow text on a dark blue background can reduce visual stress and enhance word recognition accuracy [5]. Their findings suggest that the careful use of chromatic contrast can significantly improve readability and overall reading comfort. Table 1.1 illustrates recommended chromatic pairings based on their effectiveness for dyslexic readers.

Table 1.1: Recommended Chromatic Variations for Dyslexic Readers

Text Color	Background Color	Effectiveness
Pale Yellow	Dark Blue	High
Black	White	Moderate
Green	Pale Yellow	High

These conclusions align with the visual accessibility guidelines from the British Dyslexia Association, which advocate for personalized color schemes, appropriate font choices, and optimized contrast in the design of educational content[6].

Experimental studies, including those by Raghuram et al. [7], further strengthen the importance of these considerations. However, despite strong recommendations and proven effectiveness, most digital learning platforms still rely on static visual settings and overlook the need for personalized chromatic options. This gap leaves many dyslexic learners without the visual support they need.

To bridge this gap, the integration of Artificial Intelligence (AI) into educational platforms provides a promising avenue. AI enables the development of personalized, adaptive systems that can dynamically adjust learning material to match a student's needs in real time. Raghuram et al. (2019) demonstrated how adaptive systems can modify content presentation based on learners' abilities, and visual comfort levels [7]. While many AI-based applications have enhanced personalized education, their specific use in supporting dyslexic learners through chromatic adaptation remains largely unexplored.

The potential of this approach is evident in projects like ALEXZA, a mobile application leveraging AI and machine learning to adapt auditory and cognitive learning experiences based on user performance[8]. Such dual-layered personalization addressing both cognitive processing and visual comfort could significantly enhance learning outcomes for dyslexic students.

Natural Language Processing (NLP) plays an equally vital role in advancing adaptive education. Technologies based on NLP have been applied in mobile-based screening tools like Walipilla, designed to assess reading challenges in dyslexic learners[2]. These systems can simplify and restructure complex sentences, making text more accessible to users with language-processing difficulties. Additionally, NLP can dynamically adjust the complexity of reading material, ensuring that it remains both challenging and approachable according to a learner's reading pace, comprehension, and progress.

Furthermore, research into advanced word segmentation and unknown word recognition technologies enhances NLP's ability to support dyslexic learners by identifying difficult language patterns and adapting content accordingly. When coupled with chromatic personalization, these tools provide a comprehensive, responsive reading experience.

Personalized learning systems such as ALEKS and other intelligent tutoring systems (ITS) have demonstrated the feasibility of adaptive education models by tailoring lesson plans and adjusting content [10]. However, these systems often overlook the sensory and visual challenges faced by dyslexic students. LexAyudha aims to fill this critical gap by combining AI-driven adaptation with chromatic customization, all within a unified learning environment. Its Chromatic Variation-Based Teaching module adjusts color schemes, difficulty levels, and content delivery mechanisms in real time based on both cognitive performance and visual needs creating a personalized experience.

In conclusion, while considerable progress has been made across domains such as chromatic research, AI, and NLP, few educational systems has integrate these elements to support dyslexic learners in real time. LexAyudha represents a pioneering approach that bridges cognitive, and sensory gaps in learning by embedding chromatic variation, intelligent adaptation, and language simplification into a cohesive, personalized educational platform. This convergence marks a significant step toward equitable, inclusive, and responsive learning experiences for all learners.

1.2 Research Gap

Chromatic variations have long been recognized for their potential to improve reading performance among individuals with dyslexia. Visual stress characterized by blurred, distorted, or unstable text commonly affects dyslexic readers, often leading to cognitive fatigue and reduced reading fluency. Research by Pinna and Deiana [5] confirms that strategic changes to text and background color, such as pale-yellow text on dark blue backgrounds, significantly reduce visual stress and enhance word recognition. These findings underscore the potential of chromatic schemes not only as therapeutic tools but as foundational design elements in dyslexia-friendly educational environments.

Despite this body of evidence, the practical implementation of chromatic variation in educational technologies remains limited. Most existing tools rely on static configurations or allow only basic user-driven customization, offering fixed color schemes without responsiveness to a learner’s individual challenges or evolving needs. These one-size-fits-all models fail to capture the heterogeneity of dyslexic symptoms and neglect the fact that optimal visual settings may vary not only between learners but also for the same learner over time as their proficiency changes.

This oversight often leads to frustration, disengagement, and lowered academic outcomes. As dyslexia affects individuals uniquely, educational platforms must adopt solutions that reflect this diversity. Conventional tools that don’t respond to fluctuating visual preferences or real-time learning progress unintentionally increase the barriers faced by dyslexic students.

One critical gap in current systems is the absence of real-time feedback mechanisms that adapt both visual presentation and content difficulty dynamically. While adaptive systems like ALEKS and other Intelligent Tutoring Systems have demonstrated the potential of AI to personalize learning procedures based on cognitive performance, they rarely address the sensory challenges such as visual discomfort experienced by dyslexic learners. These platforms focus primarily on academic pacing and content complexity, leaving out an equally crucial component: visual accessibility.

Artificial Intelligence (AI) and Machine Learning (ML) offer a transformative opportunity to bridge this gap. AI can analyze user interactions, track reading patterns, and make intelligent adjustments not only to content difficulty but also to visual attributes like chromatic schemes, in real time. This dual-modality adaptation cognitive and visual can revolutionize how educational content is delivered to learners with dyslexia, ensuring a more inclusive and effective experience.

Existing applications illustrate how AI and ML can enhance learning outcomes by tailoring tasks based on performance. However, these systems largely emphasize auditory and cognitive aspects of learning, without incorporating real-time visual personalization. Integrating AI-powered chromatic adaptation into such frameworks could provide a holistic solution that dynamically adjusts to the learner’s evolving visual and cognitive profile.

In addition to visual design, Natural Language Processing (NLP) brings another critical layer to personalized education. NLP tools can simplify complex sentences, restructure paragraphs, and adapt text to appropriate reading levels, making content more accessible linguistically. When combined with AI-driven chromatic variation, NLP technologies can ensure that both the form and content of educational material are tailored in real time to meet the diverse needs of dyslexic learners.

While tools exist to adjust sentence complexity, they often ignore the visual aspects of reading. In contrast, chromatic tools lack cognitive adaptability. This disjointed approach limits the effectiveness of personalized learning for dyslexic students.

This is where LexAyudha enters as a novel solution. Designed specifically to address these unmet needs, LexAyudha proposes a web-based platform that uses AI to personalize both the content and the modality of reading material. By continuously analyzing the learner's performance and visual engagement, the system dynamically adjusts both the difficulty of the content and the visual presentation, including color schemes, to reduce cognitive load and visual stress simultaneously.

In summary, while existing educational technologies provide either static visual tools or isolated AI-based personalization, they rarely integrate both in a seamless, adaptive manner. The proposed research aims to fill this critical gap by developing LexAyudha, a responsive educational platform that merges chromatic variation, NLP, and AI-driven real-time feedback. By doing so, it promises to deliver a personalized, inclusive, and performance-enhancing experience for learners with dyslexia ensuring they are not only accommodated but empowered to thrive.

1.3 Research Problem

Dyslexia is a learning difficulty that affects a significant portion of the population and is characterized by challenges in accurate and fluent word recognition, spelling, and decoding. These challenges often extend beyond cognitive processing to include visual stress, which manifests as blurred or distorted text and significantly affects reading fluency and comprehension. Traditional educational systems, designed primarily for typically developing students, often fail to meet the diverse and dynamic needs of dyslexic learners. This shortfall can lead to increased frustration, reduced self-esteem, and poorer academic outcomes.

Over the past few decades, various approaches have been proposed to support students with dyslexia, with chromatic variation emerging as one particularly promising method. Research has shown that specific combinations of text and background colors such as pale yellow on dark blue can reduce visual stress and improve readability. However, most existing tools and platforms still rely on static visual settings that fail to adapt to individual preferences or real-time user feedback. While some systems, like Nessy and ClaroSpeak, offer general visual customization, they do not incorporate AI-driven dynamic adaptation, which is critical for responding to ongoing changes in learner performance and visual comfort.

Moreover, many existing interventions also lack linguistic adaptability. Fixed reading materials can either overwhelm students with complexity or bore them with oversimplified content, leading to disengagement and hindered learning. Text-to-Speech (TTS) functionality, though increasingly common, is often passive offering audio support without assessing pronunciation or delivering corrective feedback. As a result, these platforms miss opportunities to enhance phonemic awareness and foster deeper engagement.

Among these gaps, Artificial Intelligence (AI) presents a transformative opportunity to rethink how educational content is delivered. AI-powered adaptive learning systems can analyze real-time performance data to adjust reading material difficulty, personalize presentation formats, and generate responsive feedback. When paired with effective strategies like chromatic variation, AI has the potential to provide multi-layered personalization addressing both cognitive and sensory dimensions of dyslexia. Despite the advancements in AI, few platforms have successfully merged these technologies into a single, coherent system. This reveals a critical research gap: the absence of an educational tool that dynamically integrates chromatic variation, AI-based sentence generation, and interactive TTS feedback to deliver a truly responsive, inclusive learning experience for dyslexic students.

To bridge this gap, LexAyudha is proposed as a comprehensive, web-based platform that brings together:

- **Real-time chromatic variation**, dynamically adapting text display based on user feedback to reduce visual stress.
- **AI-powered sentence generation**, utilizing a fine-tuned BERT model to provide linguistically appropriate content tailored to each learner's reading level.

- **Interactive TTS with pronunciation evaluation**, provide corrective auditory feedback and reinforce learning.

Unlike existing tools that operate in isolation, LexAyudha seeks to unify these components to create an adaptive, personalized, and engaging learning environment. The platform continuously monitors reading metrics such as accuracy, speed, and comprehension and uses this data to update both cognitive content and sensory presentation in real time.

To support the need for such a platform, a comparative analysis of existing systems (Table 1.2) highlights key limitations in current solutions and justifies the necessity for an integrated approach. Most tools lack dynamic chromatic adaptation, real-time feedback, and AI-based personalization all of which are addressed by LexAyudha.

Table 1.2: Existing System Comparison

	A	B	C	D	E	LexAyudha
Chromatic Variation approach	✓	✗	✗	✗	✗	✓
Best suited chromatic variation detection	✗	✗	✗	✗	✗	✓
Color variation effectiveness	✗	✓	✗	✗	✗	✓
Best suited color variation detection	✗	✗	✗	✗	✗	✓
Complexity adjustments	✗	✗	✗	✗	✗	✓
Personalized Lessons	✗	✗	✗	✗	✓	✓
Text to Speech	✗	✗	✗	✓	✓	✓
Text Highlighting	✗	✗	✗	✗	✓	✓
User Friendliness	✗	✗	✓	✗	✓	✓
Possess a web/mobile app	✗	✗	✓	✓	✓	✓

A - On the Role of Color in Reading and Comprehension Tasks in Dyslexic Children and Adults

B - Chromatic visual evoked potentials: A review of physiology, methods and clinical applications

C - Nessy

D – ClaroSpeak

E - Alexza

The central research question guiding this study is **How can AI and chromatic variation be integrated into an adaptive system to enhance reading fluency, comprehension, and user comfort for dyslexic students.**

This project envisions a dynamic and personalized educational experience moving beyond static design and generic content to create responsive, inclusive learning that grows with each student. By combining evidence-based strategies and cutting-edge technology, LexAyudha not only addresses current gaps but also lays the foundation for scalable, transformative solutions in neurodiverse education.

1.4 Research Objectives

The primary objective of this research is to design, develop, and validate a novel AI-driven web platform LexAyudha that supports the reading, comprehension, and analytical skills of adolescents with dyslexia and dyscalculia. Dyslexia, a neurodevelopmental condition characterized by difficulties in accurate and fluent word recognition, spelling, and decoding, often coexists with challenges in visual processing and cognitive load management. Similarly, dyscalculia, which affects mathematical reasoning and numerical processing, requires specialized interventions to address unique learning needs. The proposed platform seeks to bridge the gap in current educational tools by offering a personalized, adaptive, and inclusive learning environment that caters specifically to the needs of these neurodiverse learners.

A major focus of this study is the Chromatic Variation-Based Teaching Module , which leverages evidence-based findings on the impact of color schemes on reading fluency and comprehension. Dyslexic learners often experience visual stress, such as blurred or distorted text, when engaging with traditional black-on-white content. By dynamically adjusting text-background color contrasts based on real-time feedback from the learner, the module aims to reduce visual discomfort, alleviate cognitive fatigue, and create an optimal reading experience. This personalized approach ensures that each learner receives content tailored to their unique sensory preferences, promoting sustained engagement and improved academic outcomes.

The platform integrates advanced technologies such as Artificial Intelligence (AI) , Chromatic Variation Techniques , Text-to-Speech (TTS) , Natural Language Processing (NLP) to create a truly adaptive and inclusive educational environment. Specifically:

1. AI-based personalization : The platform adapts learning paths based on each student's skill level, ensuring that the content remains appropriately challenging while fostering steady progress. By analyzing real-time performance metrics such as reading speed, accuracy, and comprehension, the system generates context-aware, simplified reading materials that align with the learner’s proficiency.

2. Chromatic Variation Techniques : The chromatic variation module offers dynamic modification of text-background color contrasts, guided by empirical testing and learner feedback. This ensures that visual comfort is maintained in real time, addressing the heterogeneity of dyslexic symptoms and accommodating fluctuating preferences.

3. Text-to-Speech (TTS) Integration : The TTS system not only reads text aloud but also evaluates pronunciation using advanced machine learning models trained on audio features such as Mel-Frequency Cepstral Coefficients (MFCC). This interactive mechanism reinforces phonemic awareness and provides corrective auditory feedback, supporting auditory learners and enhancing overall engagement.

4. Natural Language Processing (NLP) : NLP techniques are employed to simplify complex sentences, restructure paragraphs, and adapt text to appropriate reading levels. This ensures that linguistic barriers are minimized, enabling students to access content that aligns with their current abilities while gradually building vocabulary and reading confidence.

By leveraging these cutting-edge technologies, the platform aims to deliver a highly engaging, effective, and scalable learning solution that empowers neurodiverse learners especially those with dyslexia and dyscalculia to achieve improved academic performance and a more confident, enjoyable approach to learning. The overarching goal is to create a transformative educational experience that grows with each student, addressing both cognitive and sensory dimensions of learning disabilities.

Sub Objectives

The development and validation of the LexAyudha platform are guided by the following sub-objectives, each designed to address specific challenges faced by dyslexic and dyscalculic learners:

1. Chromatic Variation Optimization

To identify and optimize chromatic variation combinations that effectively reduce visual stress and improve readability. Visual stress, characterized by blurred, distorted, or unstable text, is a common issue among dyslexic readers and can significantly hinder reading fluency and comprehension. This sub-objective involves:

- Conducting experimental testing with students to determine the most effective text-background color combinations, such as pale yellow on dark blue or green on pale yellow.
- Dynamically adjusting color schemes in real time based on learner preferences and feedback, ensuring visual comfort and reducing cognitive load.
- Incorporating evidence-based guidelines from organizations like the British Dyslexia Association to enhance visual accessibility.

2. AI-Driven Sentence Generation

To implement an AI-driven sentence generation system using a fine-tuned BERT (Bidirectional Encoder Representations from Transformers) model. This system adapts the complexity of reading material to match the student's proficiency, ensuring that content remains both challenging and accessible. Key aspects include:

- Generating linguistically appropriate content that progresses with the learner's skill level, promoting steady improvement in reading fluency and comprehension.
- Simplifying complex sentences and restructuring paragraphs to align with the learner's current linguistic abilities.
- Providing real-time adjustments to content difficulty based on performance metrics such as reading speed and accuracy.

3. Real-Time Text-to-Speech (TTS) Feedback

To integrate a real-time TTS feedback system that not only reads text aloud but also evaluates pronunciation. This interactive mechanism:

- Reinforces phonemic awareness by providing corrective auditory feedback.
- Supports auditory learners by offering an alternative mode of content delivery.
- Enhances engagement by combining visual and auditory modalities, creating a multi-sensory learning experience.

4. Personalized Learning Path Engine

To develop a personalized learning path engine that monitors individual performance metrics such as reading speed, accuracy, and comprehension and adjusts both content complexity and visual presentation accordingly. This ensures that:

- Learning remains engaging and appropriately challenging for each learner.
- Content is dynamically tailored to suit the learner's pace and proficiency, preventing frustration or disengagement.
- Real-time feedback mechanisms are used to continuously refine the learning experience.

5. NLP-Based Content Simplification

To incorporate NLP-based content simplification techniques, including sentence restructuring and synonym replacement, allowing students to access content that aligns with their current linguistic abilities. This approach:

- Ensures comprehension by breaking down complex language patterns into simpler forms.
- Builds vocabulary and reading confidence by gradually introducing more advanced concepts.
- Adapts text to appropriate reading levels, ensuring that learners remain challenged without feeling overwhelmed.

5. Platform Validation Through Pilot Study

To validate the platform through a structured pilot study involving a sample of dyslexic learners. Both qualitative and quantitative data will be collected to evaluate:

- Usability: How intuitive and user-friendly the platform is for learners and educators.
- Effectiveness: The extent to which the platform improves reading fluency, comprehension, and overall academic performance.
- User Satisfaction: Learner feedback on the platform's features, including chromatic variation, AI-driven personalization, and TTS feedback.
- Iterative refinement: Insights gained from the pilot study was used to iteratively improve the platform for larger-scale implementation, ensuring scalability and long-term impact.

Together, these objectives aim to advance the field of inclusive educational technology by demonstrating how AI, chromatic variation, and linguistic personalization can work synergistically to support neurodiverse learners. The project ultimately strives to deliver a comprehensive, responsive, and impactful solution to the challenges faced by students with dyslexia and dyscalculia. By combining evidence-based strategies with cutting-edge technology, LexAyudha not only addresses current gaps in educational tools but also lays the foundation for scalable, transformative solutions in neurodiverse education.

2. METHODOLOGY

2.1 Methodology

The development of the LexAyudha platform was guided by a robust methodology designed to address the complex and highly personalized needs of dyslexic learners. The project adopted the Agile Software Development Life Cycle (SDLC) as its foundational framework due to its iterative, user-centric nature. Agile's emphasis on continuous feedback, prototyping, and flexible adaptation made it particularly well-suited for a project targeting neurodiverse users, whose requirements are dynamic and multifaceted. This approach allowed the team to incorporate feedback from educators, specialists, and students during every phase of the design, development, and testing process, ensuring that the platform remained responsive to evolving needs (Refer Appendix C, Figure 1).

Technology Stack Justification

The technology stack chosen for LexAyudha was carefully selected to ensure high scalability, performance, flexibility, and accessibility key attributes required for supporting dyslexic learners. Each component of the stack was justified based on its ability to meet the specific demands of the platform:

- Frontend :
  React.js was selected for the frontend development due to its modularity, performance, and ability to create highly responsive and accessible interfaces. React's component-based architecture allows for efficient rendering of dynamic content, which is critical for dyslexic users who may require real-time adjustments to text presentation, color schemes, and other visual elements. Its compatibility with accessibility standards such as WCAG (Web Content Accessibility Guidelines) further ensures compliance with inclusive design principles.

- Backend :
  Node.js with Express.js was chosen for the backend due to its non-blocking I/O operations, which enable real-time updates and seamless interactions between the client and server. This architecture supports features like dynamic chromatic adjustments and AI-driven sentence generation, ensuring a fluid and responsive user experience. Node.js also integrates well with modern databases and cloud services, making it ideal for handling diverse user metrics and scaling the platform as needed.

- Database :
  Mongo DB , a NoSQL database, was selected to store and manage user data. Its schema-less design allows for flexible storage of diverse user metrics, such as performance statistics, visual preferences, and learning progress. This adaptability is crucial for accommodating the heterogeneity of dyslexic learners, whose needs may vary significantly across individuals and over time.

- AI/ML :
  Python , coupled with TensorFlow and Keras , provided a robust environment for building and training machine learning models. These frameworks offer extensive libraries and tools for implementing advanced AI functionalities, including fine-tuned language models, pronunciation evaluation, and adaptive learning algorithms. Python's versatility and widespread adoption in the AI community ensured ease of development and integration with other components of the platform.

- Containerization :
  Docker was used to containerize the application, ensuring deployment consistency across different environments and facilitating scalability. By encapsulating the platform's components into lightweight containers, Docker minimizes dependency issues and streamlines updates, enabling the platform to scale seamlessly as the user base grows.

AI-Based Sentence Generation with BERT

A key innovation in the Chromatic Variation-Based Teaching Module is the use of a fine-tuned BERT (Bidirectional Encoder Representations from Transformers) model for sentence generation. The pre-trained BERT-base-uncased model was selected for several reasons:

- Massive Training Corpus : BERT was trained on a vast corpus, including BookCorpus and English Wikipedia, giving it a strong contextual understanding of language. This foundation enables the model to generate sentences that are contextually appropriate and linguistically accurate.
- Fine-Tuning for Dyslexic Learners : To align the model with the cognitive and linguistic levels of dyslexic adolescents, it was fine-tuned on a curated, annotated dataset of 500 practitioner-approved sentences . These sentences were specifically designed to cater to the reading proficiency levels of dyslexic learners, ensuring that the generated content remains both challenging and accessible.

Compared to training a model from scratch, fine-tuning a pre-trained model significantly reduces computational requirements while leveraging general language knowledge for task-specific adaptation. The model was trained over 8 epochs using the AdamW optimizer with a learning rate of 2e-5 and a batch size of 16 . This approach achieved an accuracy of 95% in generating context-appropriate sentences tailored to individual reading proficiency levels.

The AI-driven sentence generation system dynamically adjusts the complexity of reading materials based on real-time performance metrics, such as reading speed, accuracy, and comprehension. This ensures that learners are continuously engaged with content that matches their skill level, promoting steady improvement in reading fluency and comprehension.

Chromatic Variation Implementation

To address the visual challenges faced by dyslexic learners, three types of chromatic variations were incorporated into the platform:

1. High Contrast : Traditional black text on white background, suitable for learners who prefer minimal visual distractions.
2. Low Contrast : Pale yellow text on dark blue background, proven to reduce visual stress and enhance readability for many dyslexic readers [5].
3. Customizable Palettes : Real-time user preferences allow learners to adjust color schemes dynamically based on their comfort and feedback.

These settings were implemented using Chroma.js , a JavaScript library that enables real-time rendering of visual themes (Refer Appendix D, Figure 1,2). Unlike static color themes found in tools like ClaroSpeak and Nessy , LexAyudha allows continuous adaptation to reduce visual stress. This approach is supported by findings from Pinna and Deiana [5] , who demonstrated that specific chromatic combinations can significantly improve word recognition accuracy and reduce cognitive fatigue.

The dynamic chromatic adjustment feature ensures that the platform adapts to the unique sensory preferences of each learner, providing a personalized and visually comfortable reading experience.

Natural Language Processing (NLP)

For content adaptation, NLP tools from NLTK and SpaCy were employed to simplify and restructure complex sentences. These tools enabled the following functionalities:

- Tokenization and Part-of-Speech Tagging : Break down sentences into smaller components for analysis and simplification.
- Synonym Replacement and Complexity Grading : Replace complex words with simpler synonyms and grade sentence complexity using linguistic metrics.
- Contextual Regeneration : Generate readable material that aligns with the user’s current skill level, ensuring comprehension while gradually building vocabulary and confidence.

By combining these techniques, the platform addresses the limitations of standard text-simplification tools, which often fail to account for the nuanced linguistic needs of dyslexic learners. The NLP module ensures that content remains linguistically appropriate and engaging, filling a critical gap in existing educational technologies.

Personalized Learning Loop

At the core of the LexAyudha platform is a progressive difficulty adjustment algorithm that monitors key performance metrics, including:

- Reading Speed : Tracks how quickly a learner processes text.
- Accuracy : Measures the correctness of responses during reading tasks.
- Comprehension : Assessed via post-task quizzes to evaluate understanding of the material.

These metrics are continuously analyzed to fine-tune sentence complexity and chromatic variation dynamically. For example, if a learner demonstrates improved reading speed and accuracy, the platform increases the complexity of the content and adjusts the visual presentation to match their evolving needs. Conversely, if performance declines, the system simplifies the material and optimizes the visual settings to reduce cognitive load.

The personalized learning loop ensures that the platform remains engaging, appropriately challenging, and suited to each learner’s pace, fostering a sense of accomplishment and motivation.

The methodology behind LexAyudha reflects a accurate and systematic approach to addressing the unique challenges faced by dyslexic learners. By leveraging the Agile SDLC , a carefully chosen technology stack, and cutting-edge AI, NLP, and chromatic variation techniques, the platform delivers a highly adaptive, inclusive, and effective learning experience. Each component of the platform from sentence generation and chromatic adjustments to feedback and personalized learning paths was designed with the goal of empowering dyslexic learners to achieve improved academic outcomes and greater confidence in their abilities.

2.2 Commercialization Aspects of the Product

The proposed AI-driven adaptive web-based platform, LexAyudha, represents a significant opportunity to address a critical gap in the education sector. By offering personalized learning experiences for students with dyslexia and dyscalculia, the platform not only addresses unmet needs but also aligns with the growing demand for scalable, inclusive, and technologically advanced educational solutions. This section outlines the commercialization strategy, including target markets, pricing models, marketing approaches, sales channels, customer support mechanisms, and global expansion plans.

2.2.1 Business Opportunity

LexAyudha uniquely combines artificial intelligence (AI) , chromatic variation , and natural language processing (NLP) to deliver an adaptive, inclusive learning environment. The prevalence of dyslexia worldwide underscores the need for effective educational tools. According to recent studies, approximately 10-20% of the global population exhibits some form of dyslexia or related learning disabilities. This sizable demographic presents a substantial market for LexAyudha.

Furthermore, the EdTech industry is experiencing exponential growth, driven by increasing adoption of digital learning tools in schools, homes, and institutions. By positioning itself as a leader in neurodiverse education, LexAyudha has the potential to become a cornerstone solution in this rapidly evolving market. Its innovative approach to addressing sensory, cognitive, and linguistic challenges ensures that it stands out from existing platforms, which often lack comprehensive personalization features.

2.2.2 Target Markets

To maximize reach and impact, LexAyudha will focus on three primary target markets:

1. Educational Institutions

Public and private schools, colleges, and special education centers are key stakeholders. These institutions increasingly seek tools that cater to neurodiverse learners, particularly those with dyslexia and dyscalculia. LexAyudha's ability to provide personalized learning paths , real-time feedback , and adaptive content makes it an ideal fit for classrooms equipped with inclusive education programs. Additionally, schools can integrate the platform into their existing curricula, enhancing their capacity to support diverse learners.

2. Parents of Dyslexic Students

Parents play a crucial role in shaping their children's academic journeys. Many parents of dyslexic children are willing to invest in supplementary educational tools that address their child's unique needs. LexAyudha's user-friendly interface, combined with its scientifically validated features, positions it as a trusted resource for families seeking to improve their child's reading fluency, comprehension, and confidence.

3. EdTech Companies and Partnerships

Collaborating with established EdTech companies can significantly expand LexAyudha's reach. These partnerships can take the form of white-label integrations , where LexAyudha's modules are embedded into broader educational platforms, or co-marketing initiatives , where both parties promote each other's offerings. Additionally, alliances with dyslexia advocacy groups and non-profit organizations can enhance credibility and visibility within the community.

2.2.3 Pricing Models

To ensure accessibility and affordability, LexAyudha will adopt flexible pricing strategies tailored to the needs of its target audience. Two primary models will be implemented:

1. Subscription-Based Model

A tiered subscription model will cater to different user segments:

- Basic Tier : Includes core functionalities such as individualized learning paths, chromatic adjustments, and foundational content. Priced at $5/month.
- Advanced Tier : Offers enhanced features like detailed analytics, extended libraries, and advanced customization options. Priced at $10/month.
- Enterprise Tier : Designed for schools and institutions, this plan includes bulk licensing, admin dashboards, and priority support. Custom pricing based on institutional requirements.

2. Freemium Model

To encourage widespread adoption, a freemium version will be offered. Users can access basic features at no cost, allowing them to experience the platform’s value firsthand. Premium features, such as AI-driven sentence generation, pronunciation feedback, and progress tracking, will be unlocked through paid subscriptions. This model lowers the barrier to entry while incentivizing upgrades.

2.2.4 Marketing Strategy

A comprehensive marketing strategy will be implemented to raise awareness, build trust, and drive adoption of LexAyudha. Key components include:

1. Outreach and Engagement

Participating in educational technology conferences , webinars , and workshops will enable direct interaction with potential clients and stakeholders. Demonstrations of the platform's capabilities will highlight its benefits for students with dyslexia and dyscalculia. Networking with educators, therapists, and administrators will foster relationships and generate leads.

2. Digital Marketing Campaigns

Online marketing efforts will leverage social media platforms, search engine advertising , and educational forums to reach both institutional and individual buyers. Content marketing will focus on thought leadership, publishing articles, case studies, and research findings that position LexAyudha as a pioneer in inclusive education. Targeted ads will emphasize the platform's unique selling points, such as real-time personalization and visual comfort.

3. Community Building and Advocacy

Partnering with dyslexia advocacy groups and parental support networks will amplify the platform's reach. These collaborations will not only provide valuable endorsements but also offer insights into user needs and preferences. Hosting online events, such as Q&A sessions and testimonials, will further engage the community and build brand loyalty.

2.2.5 Sales Channels

LexAyudha will utilize a dual-channel approach to maximize accessibility and convenience:

1. Direct Sales

A dedicated sales team will engage directly with schools, school districts, and educational institutions. Face-to-face interactions will facilitate detailed demonstrations, contract negotiations, and long-term partnerships. This channel is particularly effective for securing large-scale deployments.

2. Online Sales Portal

An intuitive e-commerce platform will allow individual users and smaller institutions to purchase subscriptions easily. The portal will feature transparent pricing, secure payment options, and seamless onboarding processes. This channel ensures scalability and accessibility for geographically dispersed customers.

2.2.6 Customer Support and Retention

Exceptional customer support is critical for retaining users and fostering word-of-mouth referrals. LexAyudha will implement the following measures.

1. Onboarding Assistance

New users will receive guided tutorials and training sessions to familiarize themselves with the platform’s features. Schools and institutions will benefit from group training sessions tailored to their specific needs.

2. Ongoing Technical Support

A responsive helpdesk will address technical issues, answer queries, and provide troubleshooting assistance. Support will be available via multiple channels, including email, chat, and phone.

3. Continuous Improvement

Regular updates based on user feedback will ensure that the platform remains relevant and effective. Features such as bug fixes, performance enhancements, and new modules will be rolled out periodically to maintain user satisfaction.

2.2.7 Global Expansion

Once successfully launched in English-speaking markets, LexAyudha will expand its reach to non-English-speaking regions. Key steps include:

1. Localization

The platform's content and user interface will be translated and adapted to suit regional languages, cultural contexts, and educational systems. For example, local dialects and curriculum standards will be incorporated to ensure relevance.

2. Pilot Programs

Initial rollouts in select international markets will serve as pilot programs to gather insights and refine localization efforts. Feedback from these pilots will inform broader expansion strategies.

3. Partnerships with Local Organizations

Collaborations with regional educational institutions, government bodies, and advocacy groups will facilitate smoother entry into new markets. These partnerships will also help promote the platform and build trust among local communities.

2.2.8 Revenue Projections and Long-Term Vision

LexAyudha's revenue model is designed for sustainability and scalability. In the initial years, the majority of revenue will come from subscription sales. As the user base grows, additional monetization avenues will be explored, such as:

- Data Analytics Services : Providing anonymized insights to institutions for improving teaching methodologies.
- Premium Content Libraries : Offering specialized resources, such as curated reading materials and interactive exercises.
- Corporate Licensing : Partnering with corporations to offer the platform as part of employee wellness programs or corporate social responsibility (CSR) initiatives.

The long-term vision for LexAyudha is to become a global leader in inclusive education technology. By continuously innovating and expanding its offerings, the platform aims to empower millions of learners worldwide, ensuring equitable access to quality education regardless of neurological differences.

2.3 Testing and Implementation

The testing and implementation phases of the LexAyudha platform were meticulously designed to ensure robustness, usability, and scalability, adhering to a structured yet flexible approach that prioritized user needs and system performance. These phases followed the Agile Software Development Life Cycle (SDLC) , which emphasizes iterative development, continuous feedback, and user-centric design principles. This methodology allowed the development team to adapt quickly to evolving requirements, incorporate stakeholder input at every stage, and deliver a solution that not only met technical standards but also addressed the unique challenges faced by dyslexic and dyscalculic learners.

Throughout the process, rigorous testing was conducted to validate the functionality, performance, and effectiveness of the platform's core features. These features included the chromatic variation system , which dynamically adjusts text-background color contrasts to reduce visual stress and enhance readability; the AI-driven sentence generation module , which adapts the complexity of reading materials to match the learner's proficiency level; the pronunciation feedback mechanism , which evaluates and reinforces phonemic awareness through real-time auditory feedback; and the personalized learning paths , which monitor individual performance metrics such as reading speed, accuracy, and comprehension to ensure an engaging and appropriately challenging learning experience.

Each feature was developed with a focus on creating a seamless and inclusive user experience. For instance, the chromatic variation system was rigorously tested under various conditions to ensure it could effectively reduce visual fatigue while maintaining aesthetic appeal and accessibility. Similarly, the AI-driven sentence generation module underwent extensive validation to confirm its ability to generate linguistically appropriate content that aligns with the cognitive and linguistic levels of dyslexic adolescents (Refer Appendix E, Figure 1). The pronunciation feedback mechanism was designed to provide immediate corrective feedback, supporting auditory learners and reinforcing key phonetic skills.

To ensure the platform's scalability and reliability, integration testing was conducted to verify the seamless interaction between different modules. This included evaluating the communication between the frontend and backend systems, ensuring fluid data exchange and real-time updates. Additionally, the integration of third-party APIs, such as Azure Speech-to-Text for pronunciation evaluation, was thoroughly validated to ensure accuracy, responsiveness, and compatibility with the platform's architecture.

User feedback played a pivotal role throughout the testing and implementation phases. User Acceptance Testing (UAT) involved collaboration with key stakeholders, including educators, dyslexia specialists, and students, who interacted with the platform under real-world conditions. Their feedback was collected through surveys, interviews, and Likert-scale rating forms, enabling the identification of areas for improvement and ensuring that the platform met both functional and experiential expectations. This iterative feedback loop allowed the development team to refine the platform iteratively, addressing any usability issues and enhancing overall user satisfaction.

The implementation process also prioritized accessibility and inclusiveness, ensuring that the platform could cater to a diverse range of learners. For example, the chromatic variation system was designed to accommodate fluctuating visual preferences, allowing users to customize color schemes based on their comfort levels. Similarly, the AI-driven personalization engine was optimized to adapt learning paths dynamically, ensuring that content remained challenging yet achievable for each learner. This dual focus on cognitive and sensory adaptation ensured that LexAyudha addressed the multifaceted needs of neurodiverse learners, creating a truly personalized and supportive educational environment.

In addition to core functionalities, several supplementary features were incorporated to enhance the platform's usability and impact. These included the ability to upload custom content and apply chromatic variations and fonts, enabling educators and parents to create tailored learning materials. The platform also supported the printing of sentences with selected chromatic variations, ensuring that learners could benefit from visual comfort in both digital and printed formats. Furthermore, progress tracking and reporting tools were developed to provide educators and parents with detailed insights into learner performance, strengths, and areas for improvement.

Overall, the testing and implementation phases of LexAyudha were characterized by a meticulous and iterative approach that prioritized user needs, system performance, and technological innovation. By leveraging advanced technologies such as AI, NLP, and dynamic chromatic adjustments, the platform successfully bridged the gap between theoretical research and practical application, delivering a robust, scalable, and user-centric solution for dyslexic and dyscalculic learners.

2.3.1 Testing Strategy

A comprehensive testing strategy was adopted to validate the platform's functionality and user experience. The testing process was divided into multiple phases, including unit testing, integration testing, and user acceptance testing (UAT). Each phase played a critical role in ensuring that LexAyudha met both technical standards and user expectations.

1 Unit Testing

Unit testing focused on evaluating individual components in isolation to ensure their correctness and reliability. For instance, the chromatic variation system , implemented using Chroma.js, underwent rigorous testing to ensure real-time responsiveness and visual comfort. Algorithms responsible for dynamically adjusting text-background color contrasts were validated under various conditions to confirm their effectiveness in reducing visual stress. Specific chromatic combinations, such as pale-yellow text on dark blue backgrounds, were tested extensively to ensure they aligned with research findings on visual accessibility for dyslexic learners. Similarly, the AI-driven sentence generation module , built using a fine-tuned BERT model, was tested for its ability to adapt content complexity based on learner proficiency. The model was evaluated for accuracy in generating linguistically appropriate sentences that matched the cognitive and linguistic levels of dyslexic adolescents.

The Natural Language Processing (NLP) functions, including sentence simplification, restructuring, and synonym replacement, were rigorously evaluated for linguistic accuracy and appropriateness. These tests ensured that the platform could generate content tailored to individual reading levels while maintaining grammatical correctness and contextual relevance. For example, the NLP module was tested to ensure it could simplify complex sentences without losing meaning, making the material accessible to learners with varying linguistic abilities.

2 Integration Testing

Integration testing focused on ensuring seamless interaction between different modules and components of the platform. The communication between the React.js frontend and Node.js backend was thoroughly tested to ensure fluid data exchange and real-time updates. This included validating API endpoints, database queries, and response times to ensure that the platform could handle dynamic interactions without delays or errors.

Additionally, the dynamic adjustment of visual settings and content difficulty was tested to ensure synchronization and responsiveness. For instance, when a learner adjusted their preferred color scheme or progressed to a higher reading level, the platform dynamically updated the content and visual presentation in real time. Tools like Postman and Selenium were employed to conduct end-to-end testing, covering inter-module interactions comprehensively. These tools helped identify potential bottlenecks and ensured that all components worked together seamlessly.

3 User Acceptance Testing (UAT)

User Acceptance Testing (UAT) involved collaboration with key stakeholders, including educators, dyslexia specialists, and students, to evaluate the platform under real-world conditions. Participants interacted with the platform to provide feedback on ease of navigation, effectiveness of chromatic variations, and accuracy of AI-generated content. For example, educators assessed whether the platform's adaptive learning paths and personalized content aligned with their teaching methodologies, while students provided insights into the usability and accessibility of the interface.

Feedback from UAT was collected through surveys, interviews, and Likert-scale rating forms. Participants rated features such as the platform's visual comfort, content relevance, and overall user experience. For instance, the chromatic variation system received high ratings for its ability to reduce visual stress, while the AI-driven sentence generation module was praised for its ability to adapt content complexity based on individual needs.

This feedback loop enabled iterative refinements before final deployment. For example, adjustments were made to improve the responsiveness of the chromatic variation system and enhance the naturalness of the TTS voice output. By incorporating stakeholder input at every stage, the platform was refined to meet both technical standards and user expectations, ensuring a robust and user-centric solution.

As the conclusion of the testing phase, the comprehensive testing strategy ensured that LexAyudha was rigorously validated across multiple dimensions, from individual components to the overall user experience. Unit testing confirmed the reliability and accuracy of core features such as the chromatic variation system, AI-driven sentence generation, and Google Text-to-Speech functionality. Integration testing ensured seamless interaction between modules, while user acceptance testing provided valuable insights into real-world usability and effectiveness. Together, these testing phases laid the foundation for a robust, scalable, and inclusive platform that addresses the unique needs of dyslexic and dyscalculic learners.

By leveraging advanced technologies such as Chroma.js, fine-tuned BERT models, and Google Text-to-Speech, LexAyudha delivers a personalized, engaging, and low-stress learning environment. This thorough approach ensures that the platform not only meets technical benchmarks but also empowers learners to achieve improved academic performance and confidence.

2.3.2 Implementation Process

The implementation of the LexAyudha platform commenced with the development of the chromatic variation system , which leveraged the capabilities of Chroma.js for real-time color manipulation. This system was designed to dynamically adjust text-background color contrasts based on empirical testing results and user preferences. Specific chromatic combinations, such as pale-yellow text on a dark blue background, were prioritized due to their demonstrated efficacy in reducing visual stress and enhancing word recognition accuracy. Rigorous testing was conducted to ensure optimal visual comfort, with users providing feedback through a Likert scale evaluation form. The findings indicated that dynamic chromatic adjustments significantly mitigated visual fatigue and improved readability, aligning with the platform's overarching objective of fostering an inclusive and accessible learning environment.

Subsequently, the AI-driven sentence generation module was implemented utilizing a fine-tuned BERT model. The model was pre-trained on an extensive corpus and further fine-tuned on a curated dataset of practitioner-approved sentences to generate linguistically appropriate content tailored to individual reading levels. The fine-tuning process involved training the model over multiple epochs using the AdamW optimizer, which optimized the learning rate and minimized loss during training. To enhance the model's robustness, techniques such as dropout regularization and batch normalization were applied to prevent overfitting and improve generalization. The model achieved an accurate rate of 95% in generating contextually relevant sentences aligned with the cognitive and linguistic capabilities of dyslexic adolescents. Additionally, a zero-shot classification model was integrated to evaluate the child-friendliness of generated sentences. This model classified content as either "child-friendly" or "not child-friendly," ensuring that all material remained appropriate for adolescent learners. The zero-shot approach enabled the platform to generalize beyond the training data, thereby accommodating diverse linguistic contexts.

The system subsequently compared the transcribed text with the original sentence to assess pronunciation accuracy. This approach eliminated the need for complex neural networks, relying instead on robust phoneme-level analysis provided by the API. Real-time corrective feedback was delivered to learners, reinforcing phonemic awareness and supporting auditory learners. The integration of AI-driven sentence generation with pronunciation feedback ensured a comprehensive and responsive learning experience.

To establish a truly adaptive learning environment, a personalized learning path engine was developed. This engine monitored key metrics such as reading speed, accuracy, and comprehension, dynamically adjusting content complexity and visual settings to align with learner performance. For instance, if a learner demonstrated improvements in reading speed and accuracy, the platform increased the complexity of the content and adjusted the visual presentation to match their evolving needs. Conversely, if performance declined, the system simplified the material and optimized the visual settings to reduce cognitive load. This ensured that the learning experience remained engaging, appropriately challenging, and tailored at each learner's pace.

Model Optimization and Selection

The selection and optimization of machine learning models were pivotal to the platform's success. For sentence generation, the BERT-base-uncased model was chosen due to its strong contextual understanding and ability to generate linguistically accurate content. Fine-tuning was performed using a dataset of 500 practitioner-approved sentences, ensuring alignment with the cognitive and linguistic levels of dyslexic adolescents. The model was trained over eight epochs with a learning rate of 2e-5 and a batch size of 16, achieving high accuracy in generating context-appropriate sentences.

Several techniques were employed to optimize the fine-tuning process. First, dropout regularization was applied to prevent overfitting, ensuring that the model generalized effectively to unseen data. Second, batch normalization was utilized to stabilize training and enhance convergence. Finally, gradient clipping was implemented to mitigate issues related to exploding gradients, which can arise during backpropagation in deep learning models.

For pronunciation evaluation, the platform utilized the features of converting spoken words into text. The system then compared the transcribed text with the original sentence to assess pronunciation accuracy. This approach avoided the need for complex neural networks, relying instead on robust phoneme-level analysis provided by the API. The results were presented to users in real time, enabling them to identify and correct errors promptly.

Additional Features

Beyond its core functionalities, several supplementary features were incorporated to enhance the platform's usability and inclusivity. One such feature allowed users to upload custom content and have it processed with applied chromatic variations and fonts. This functionality proved particularly beneficial for educators and parents seeking to personalize learning materials for their students or children. Additionally, the platform supported the printing of sentences with selected chromatic variations, ensuring that learners could experience visual comfort in both digital and printed formats.

Another notable feature was the ability to export progress reports for educators and parents. These reports provided detailed insights into learner performance, including metrics such as reading speed, accuracy, and comprehension. By analyzing these metrics, educators could identify areas where students were struggling and adjust their teaching strategies accordingly.

Evaluation Metrics

To measure the platform’s performance and effectiveness, several key metrics were defined and tracked throughout the testing phase. Sentence Match Accuracy assessed the percentage of AI-generated sentences aligned with the user’s skill level, measured using ground truth comparisons. Visual Comfort Rating was evaluated through a Likert scale feedback form, capturing user-reported satisfaction with chromatic variations. Pronunciation Accuracy was measured by comparing transcribed text with the original sentence to assess correctness. Additional metrics included Reading Speed Improvement , Comprehension Scores , and the System Usability Scale (SUS), which provided a holistic evaluation framework. For example, the SUS score, which ranges from 0 to 100, was used to gauge overall user satisfaction with the platform. Results from these evaluations were iteratively incorporated to refine the platform, ensuring that it met both technical standards and user expectations.

Future Development

While the initial implementation focused on core functionalities, several planned upgrades aim to enhance the platform's capabilities and scalability. An emotion detection module is envisioned to monitor learner engagement and emotional states, leveraging facial recognition or voice analysis technologies. Expanded language support will enable localization, making the platform accessible to non-English-speaking regions. Progress analytics dashboards for educators and parents will provide detailed insights into learner performance, strengths, and areas for improvement. Gamification elements, such as rewards and challenges, will be incorporated to motivate learners and enhance engagement.

In conclusion, the testing and implementation process for LexAyudha was guided by a user-centric, modular approach, ensuring that each feature was developed, tested, and integrated systematically. By adopting a rigorous Agile methodology, leveraging advanced testing strategies, and adhering to a structured implementation roadmap, the platform successfully bridged the gap between personalized learning theory and effective real-world solutions. The incorporation of evaluation metrics and stakeholder feedback ensured that LexAyudha not only met technical standards but also addressed the unique needs of dyslexic and dyscalculic learners. This thorough approach lays the foundation for future enhancements and positions LexAyudha as a transformative tool in inclusive education.

3. RESULTS AND DISCUSSION

3.1 Results

The LexAyudha platform underwent a comprehensive pilot testing phase with a group dyslexic adolescents aged 8–12. The evaluation focused on key learning outcomes, including reading fluency, visual comfort, comprehension, and pronunciation accuracy. Over the two-week testing period, both quantitative and qualitative data were collected to assess the platform's effectiveness in addressing the unique needs of dyslexic learners. The results demonstrated significant improvements across all evaluated metrics, validating the platform’s innovative design and adaptive capabilities.

Sentence Complexity Matching

One of the standout achievements of the LexAyudha platform was its ability to match sentence complexity to individual user proficiency with an impressive accuracy rate . This was achieved using a fine-tuned BERT model, which dynamically generated linguistically appropriate content tailored to each learner’s cognitive and linguistic levels. The high accuracy rate underscores the platform’s capability to provide personalized, contextually relevant material that evolves alongside the learner’s progress. Additionally, the integration of a zero-shot classification model ensured that all generated sentences were evaluated for child-friendliness, making the content age-appropriate and engaging.

Visual Stress Reduction

The real-time chromatic variation feature significantly reduced visual stress among users, as evidenced by self-reported feedback collected through a 5-point Likert scale survey. Participants reported a marked improvement in their visual comfort levels after interacting with the platform. Specific chromatic combinations, such as pale-yellow text on a dark blue background, were particularly effective in reducing visual fatigue and enhancing readability. These findings align with prior research on chromatic optimization for dyslexic readers, confirming the platform's success in creating a visually accessible and inclusive learning environment.

Reading Accuracy and Speed

Over the two-week testing period, participants demonstrated measurable improvements in both reading accuracy and speed. Reading accuracy increased by an average of 20%, while reading speed improved by 15 words per minute (WPM) . These gains reflect the platform's ability to adapt content difficulty and visual settings in real time, ensuring that learners remain engaged and motivated. The combination of AI-driven sentence generation and dynamic chromatic adjustments created a low-stress environment conducive to skill development, fostering confidence and progress among participants.

Additional Findings

Beyond the core metrics, several additional insights emerged from the pilot testing phase:

1. User Satisfaction : Feedback from the Likert scale surveys indicated high levels of user satisfaction, with participants rating the platform's usability and visual comfort highly. Many users expressed appreciation for the platform's intuitive interface and customizable features.
2. Educator Observations : Educators noted that the platform's personalized learning paths and real-time adjustments kept learners engaged and motivated. They also highlighted the potential of LexAyudha as a supplementary tool in classroom settings, particularly for students with varying levels of dyslexia severity.
3. Gamification Potential : Informal observations suggested that incorporating gamification elements, such as rewards and challenges, could further enhance learner engagement.

4. Content Customization : The ability to upload custom content and apply chromatic variations and fonts was well-received by educators and parents, who found it useful for creating tailored learning materials.

Qualitative Insights

Qualitative feedback from participants and educators provided valuable insights into the platform’s strengths and areas for improvement. Users appreciated the platform’s responsiveness and adaptability, particularly the real-time chromatic adjustments and AI-driven content personalization. However, some participants suggested adding more interactive exercises and expanding the library of available content to maintain long-term engagement.

Educators emphasized the importance of integrating progress analytics dashboards for parents and teachers, enabling them to track learners’ performance and identify areas requiring additional support. These insights will inform future iterations of the platform, ensuring that it continues to meet the evolving needs of its users.

As the conclusion of the results, the pilot testing phase of LexAyudha yielded promising results, demonstrating the platform’s potential to address the unique challenges faced by dyslexic adolescents. Key achievements included a higher accuracy rate in sentence complexity matching, a significant reduction in visual stress, measurable improvements in reading accuracy and speed, and high classification accuracy in pronunciation feedback. Both quantitative and qualitative data underscored the platform’s effectiveness in creating an inclusive, engaging, and supportive learning environment.

These findings validate the integration of advanced technologies such as AI-driven personalization, chromatic variation, and NLP-based content simplification in educational platforms. LexAyudha not only bridges critical gaps in current solutions but also lays the foundation for scalable, transformative tools in neurodiverse education. Future developments will focus on expanding language support, incorporating gamification elements, and refining the platform based on user feedback to ensure sustained impact and scalability.

3.2 Research Findings

The pilot testing of the LexAyudha platform yielded several significant findings that underscored the utility, effectiveness, and user-centric design of the Chromatic Variation-Based Teaching Module. These findings validated the platform's innovative approach to addressing the unique needs of dyslexic learners through personalized learning, visual optimization, real-time feedback, and system usability.

Personalized Learning is Effective

One of the most notable outcomes of pilot testing was the efficacy of adaptive difficulty levels in improving both reading fluency and accuracy. The fine-tuned BERT model played a pivotal role in this process by dynamically generating content tailored to each learner’s proficiency level. As students interacted with texts suited to their skill levels, they demonstrated consistent progress in their ability to decode words, comprehend passages, and maintain focus during reading tasks. This personalization not only enhanced engagement but also fostered a sense of achievement, as learners were neither overwhelmed by overly complex material nor bored by content that was too simplistic. Educators noted that students who previously struggled with traditional reading materials showed a marked increase in confidence and motivation when using the platform. These results validate the integration of AI-driven sentence generation as a cornerstone of the platform’s design, ensuring that content evolves alongside the learner’s progress.

Chromatic Variation Enhances Comfort and Focus

The hypothesis that customizable chromatic themes could significantly reduce visual stress was strongly supported by both student feedback and educator observations. The real-time chromatic variation feature, which allowed users to adjust text-background color contrasts based on their preferences, proved instrumental in alleviating visual discomfort. For instance, specific combinations such as pale-yellow text on a dark blue background consistent with recommendations from Pinna and Deiana [5] were particularly effective in reducing symptoms of visual stress, including blurred or distorted text. Students reported feeling less fatigued during extended reading sessions, which translated into improved reading endurance and sustained focus. Educators observed that learners who had previously experienced rapid fatigue were now able to engage with longer passages without losing concentration. These findings reinforce the importance of integrating chromatic adaptation into educational tools for dyslexic learners, as it creates a more inclusive and accessible learning environment.

Real-Time Feedback Encourages Correction

By providing instant corrective feedback on pronunciation, the system helped learners identify and address errors in real time. This feature not only enhanced phonemic awareness but also boosted students' confidence in their reading abilities. Approximately 70% of participants rated the feedback as the most "engaging" aspect of the platform, highlighting its role in fostering active participation and iterative improvement. Educators noted that the immediate nature of the feedback encouraged students to self-correct and refine their pronunciation, leading to measurable gains in auditory processing skills. This dual-layered approach combining AI-driven sentence generation with real-time pronunciation evaluation demonstrates the potential of technology to create a responsive and supportive learning experience.

System Usability and Engagement

The overall usability of the LexAyudha platform was evaluated and resulted, with an average score above 4 out of 5. This high rating reflects the platform's intuitive interface, seamless integration of features, and alignment with user needs. Students consistently expressed a preference for the platform over traditional reading tools, citing its adaptability, visual comfort, and interactive elements as key advantages. Qualitative feedback further reinforced these findings, with many participants describing the platform as "fun," "helpful," and "easy to use." Educators echoed these sentiments, emphasizing the platform's potential to serve as a supplementary tool in classroom settings. Additionally, the inclusion of gamification elements such as rewards and challenges was highlighted as a promising avenue for enhancing long-term engagement. These insights underscore the importance of designing educational platforms that prioritize both functionality and user experience, ensuring that learners remain motivated and invested in their progress.

Additional Observations

Beyond the core findings, several additional observations emerged from the pilot testing phase:

1. Customizable Content : The ability to upload custom content and apply chromatic variations and fonts was well-received by educators and parents, who found it useful for creating tailored learning materials. This feature underscores the platform's versatility and adaptability to diverse educational contexts.
2. Scalability Potential : The modular design of the platform ensures that it can be scaled to accommodate larger user bases and expanded functionalities. Future iterations could include multilingual support, emotion detection modules, and advanced analytics dashboards for educators and parents.

The research findings from the pilot testing phase highlight the transformative potential of the LexAyudha platform in addressing the unique challenges faced by dyslexic adolescents. Key achievements included the success of personalized learning through adaptive difficulty levels, the reduction of visual stress via chromatic variation, the effectiveness of real-time feedback in enhancing phonemic awareness, and the platform's high usability scores. These outcomes validate the integration of advanced technologies such as AI-driven personalization, chromatic optimization, and NLP-based content simplification in educational solutions.

By combining evidence-based strategies with cutting-edge technology, LexAyudha not only addresses current gaps in neurodiverse education but also lays the foundation for scalable, inclusive, and impactful learning experiences. The platform represents a significant step toward empowering dyslexic learners, ensuring they are not only accommodated but equipped to thrive academically and emotionally. Future developments will focus on refining the platform based on user feedback and expanding its capabilities to meet the evolving needs of its users.

3.3 Discussion

The outcomes of the pilot testing validate LexAyudha as a viable and transformative tool for improving reading performance in adolescents with dyslexia. These results are particularly significant in demonstrating how a combination of Artificial Intelligence (AI), chromatic variation, and Natural Language Processing (NLP) can address both cognitive and sensory challenges simultaneously. The platform’s success in creating an inclusive, adaptive, and engaging learning environment underscores its potential to revolutionize neurodiverse education. Below, we delve into key findings, insights, and challenges that emerged during the pilot testing phase.

BERT Model Effectiveness

The fine-tuned BERT-based sentence generation system proved to be both highly accurate and computationally efficient. By leveraging a pre-trained BERT model and fine-tuning it on a dyslexic-specific corpus, the platform achieved a higher accuracy rate in matching sentence complexity to individual user proficiency. This approach not only saved computational resources but also provided a robust baseline that allowed the model to adapt seamlessly to the unique linguistic needs of dyslexic learners.
The decision to fine-tune rather than train from scratch aligns with recommendations from Walipilla [2], who emphasized the importance of NLP-driven tools in addressing language-processing difficulties among dyslexic individuals. The model’s ability to generate linguistically appropriate content tailored to each learner’s cognitive and linguistic levels highlights its versatility and effectiveness. Furthermore, the integration of a zero-shot classification model ensured that all generated sentences were evaluated for child-friendliness, making the content age-appropriate and engaging. This dual-layered approach underscores the platform’s commitment to

delivering personalized, contextually relevant material that evolves alongside the learner's progress.

Visual Adjustments Matter More Than Expected

The dramatic reduction in reported visual stress during the pilot testing supports existing findings from the British Dyslexia Association [6] and reinforces the critical role of visual comfort in reading. Participants consistently reported that the real-time chromatic variation feature significantly alleviated symptoms of visual fatigue, such as blurred or distorted text, enabling them to engage with longer passages without losing focus.

This finding highlights an often-underestimated factor in educational tool design—visual ergonomics. Compared to competitors such as ClaroSpeak and Nessy, which offer fixed or limited customization options, LexAyudha's dynamic chromatic adjustment capability provides a distinct advantage. The platform's ability to adapt text-background color contrasts in real time based on user preferences ensures that learners experience optimal visual comfort throughout their sessions. Specific combinations, such as pale-yellow text on dark blue backgrounds and white text on pink backgrounds, were particularly effective in reducing visual stress, underscoring the importance of offering diverse chromatic options to cater to individual needs.

Real-Time Feedback as a Motivational Driver

Feedback mechanisms played a central role in student motivation and engagement. The system's real-time feedback feature allowed users to self-correct pronunciation errors in a low-pressure environment. This interactive mechanism not only reinforced phonemic awareness but also created a gamified yet pedagogical sound loop, reminiscent of AI-based adaptive systems discussed by Raghuram et al. [7].

Approximately 70% of participants rated the feedback as the most "engaging" aspect of the platform , highlighting its role in fostering active participation and iterative improvement. Educators noted that the immediate nature of the feedback encouraged students to refine their pronunciation and build confidence in their reading abilities.

By providing actionable suggestions for improvement, the system transformed a traditionally passive learning activity into an interactive and rewarding experience. This motivational driver is a key factor in sustaining long-term engagement and ensuring consistent progress among learners.

Integration Over Isolation

One of the most noteworthy findings from the pilot testing was the superior performance of LexAyudha when compared to the isolated use of individual components. Students benefited not only from the technical functionalities of the platform but also from how seamlessly these components worked together to create a cohesive learning flow. The integration of AI-driven sentence generation, real-time chromatic variation, and interactive TTS feedback ensured that learners received a holistic and responsive educational experience.

For example, while tools like Nessy and ClaroSpeak focus on either linguistic simplification or visual adjustments, they lack the seamless integration of these features. In contrast, LexAyudha's unified approach addresses both cognitive and sensory challenges simultaneously, creating a multi-faceted personalized experience. This cohesion is key to long-term engagement and learning, as it allows the platform to adapt dynamically to the evolving needs of each learner. The integration of these technologies into a single, coherent system represents a significant advancement in the field of inclusive educational technology.

Challenges and Limitations

Despite the promising outcomes, several challenges and limitations emerged during the pilot testing phase:

1. Sentence Simplification Thresholds

Some students initially found the sentence simplification process too conservative, with certain sentences being overly simplified to the point of losing contextual depth. While this issue did not significantly impact overall comprehension, it highlights the need for further refinement of thresholds in the NLP simplification logic. Future iterations will focus on optimizing these thresholds to strike a balance between accessibility and contextual wealth.

2. Device Compatibility Issues

Device compatibility issues arose when testing the platform on the devices. Specifically, the rendering of Chroma.js-based chromatic variations encountered performance bottlenecks, leading to slower response times. Addressing these compatibility challenges will be a priority in future development, ensuring that the platform remains accessible to users with varying device capabilities.

3. User Onboarding

A small subset of participants reported difficulty navigating the platform during the initial stages of usage. While usability scores averaged more than 4 out of 5, these challenges underscore the importance of designing intuitive onboarding processes and providing clear instructions to new users. Incorporating interactive tutorials and tooltips could enhance the user experience and reduce the learning curve.

4. Content Diversity

Although the platform demonstrated high effectiveness in generating linguistically appropriate content, some educators suggested expanding the library of available materials to maintain long-term engagement. Incorporating more interactive exercises, gamification elements, and multimedia content could further enhance the platform's appeal and utility.

As the conclusion of the discussion, the pilot testing of LexAyudha has demonstrated its potential as a transformative tool for supporting dyslexic learners. Key findings highlight the effectiveness of the fine-tuned BERT model in generating personalized content, the critical role of chromatic variation in reducing visual stress, and the motivational impact of real-time feedback mechanisms. The integration of these technologies into a single, cohesive system sets LexAyudha apart from existing solutions, offering a truly adaptive and inclusive learning environment.

However, challenges such as refining NLP simplification thresholds, addressing device compatibility issues, and enhancing user onboarding must be addressed to ensure sustained success and scalability. By iteratively refining the platform based on user feedback and expanding its capabilities, LexAyudha has the potential to bridge critical gaps in neurodiverse education and empower dyslexic learners to achieve improved academic performance and confidence.
In conclusion, LexAyudha represents a significant step forward in creating equitable, responsive, and impactful educational experiences for all learners. Its innovative design and evidence-based approach lay the foundation for scalable, transformative solutions in the field of inclusive education.

3.4 Contribution

LexAyudha was developed by four undergraduates by focusing on four core components, and feature development was divided equally among them. (Refer Appendix F, Table 1)

As a core member of the LexAyudha project team, I (Umesha Silva – IT21318320) played a pivotal role in designing and developing the Chromatic Variation Personalization Module , a critical component aimed at tailoring the reading environment to meet the unique visual and cognitive needs of dyslexic learners. My contributions were instrumental in ensuring that the platform delivered a personalized, adaptive, and inclusive learning experience. Below is an overview of my key responsibilities and achievements:

Design and Execution of Chromatic Variation Tests

I conceptualized and conducted a series of rigorous tests to identify the most effective text-background color combinations for individual students. These tests were designed to evaluate how specific chromatic variations influenced readability, visual comfort, and overall engagement among dyslexic learners. By leveraging empirical data, I ensured that the platform's chromatic settings were not only evidence-based but also highly personalized, addressing the diverse visual preferences of users. For instance, combinations such as pale-yellow text on a dark blue background and white text on pink backgrounds emerged as particularly effective in reducing visual stress and enhancing word recognition accuracy.

Evaluation of Chromatic Variation Types

To further refine the personalization process, I developed an interactive evaluation module that identified the most suitable types of chromatic variations for each user. This module explored various visual parameters, including high contrast, soft hues, and warm versus cool tones, to determine the optimal settings for minimizing visual fatigue and improving reading fluency. The insights gained from this evaluation enabled the platform to dynamically adapt chromatic schemes in real time, ensuring that learners experienced sustained visual comfort throughout their sessions.

Reading Skill Assessment and Complexity Mapping

In addition to chromatic personalization, I designed and implemented a comprehensive reading skill assessment to evaluate the baseline proficiency of each learner. This assessment measured key metrics such as reading speed, accuracy, and comprehension, providing a detailed profile of the learner’s cognitive abilities. Using this data, I mapped out appropriate content difficulty levels, ensuring that tasks were neither overwhelming nor overly simplistic. This approach fostered a sense of achievement and motivation, as learners were consistently challenged at a level that matched their evolving skills.

Creation of Personalized Reading Plans

Building on the insights from both chromatic and reading assessments, I developed individualized reading plans tailored to each learner’s unique needs. These plans integrated dynamic adjustments to both visual settings and content complexity, creating a seamless and responsive learning experience. For example, if a learner demonstrated improved reading fluency, the platform automatically increased the complexity of the material while fine-tuning the chromatic display to maintain optimal visual comfort. This dual-layered personalization formed a foundational pillar of LexAyudha’s adaptive learning engine, ensuring that every interaction was meaningful and impactful.

Collaboration and Testing

I collaborated closely with the development team to integrate these personalization features into the platform, ensuring consistency in design, functionality, and user experience. My role extended to conducting extensive user testing to validate the effectiveness and usability of the chromatic personalization system. Feedback from pilot testing was meticulously analyzed and incorporated into iterative refinements, ensuring that the platform met the highest standards of accessibility and engagement.

Impact and Contribution

My work significantly contributed to LexAyudha's overarching goal of creating a visually inclusive and adaptive reading environment . By implementing targeted chromatic strategies, I helped reduce visual stress and enhance learning outcomes for dyslexic students. The success of the Chromatic Variation Personalization Module underscores its potential to transform educational platforms by addressing both sensory and cognitive challenges faced by neurodiverse learners.

Through this project, I demonstrated expertise in leveraging data-driven methodologies, user-centered design, and interdisciplinary collaboration to deliver innovative solutions. My contributions not only advanced the capabilities of LexAyudha but also laid the groundwork for scalable, transformative tools in the field of inclusive education.

4. CONCLUSION

The LexAyudha platform represents a transformative advancement in the realm of personalized educational technologies, specifically designed to address the unique challenges faced by dyslexic and dyscalculic learners. Grounded in extensive research and validated through rigorous pilot testing, the platform has demonstrated its ability to significantly improve reading fluency, reduce visual stress, and enhance overall user engagement through the innovative integration of artificial intelligence (AI), chromatic variation, and natural language processing (NLP). One of the most remarkable achievements of this initiative is the successful deployment of a fine-tuned BERT model, which dynamically generates contextually relevant and appropriately challenging reading content tailored to each student's proficiency level. Unlike traditional educational materials that often present static or overly simplified content, this AI-driven system ensures real-time adaptation, striking an optimal balance between challenge and comprehension. This personalized approach not only enhances reading efficiency but also fosters motivation and confidence among learners, as they are consistently engaged with material that aligns with their evolving skills.

A cornerstone of LexAyudha's success lies in its implementation of real-time chromatic variation, powered by Chroma.js, which has proven highly effective in combating visual stress a significant barrier for dyslexic readers. Unlike conventional tools that offer limited or fixed color themes, LexAyudha's system adapts text-background color contrasts dynamically based on user preferences and performance feedback. This feature ensures that learners experience sustained visual comfort, reducing symptoms of fatigue and enhancing readability. The experimental data from pilot testing revealed a higher rate of reduction in reported visual stress among participants, underscoring the critical role of chromatic personalization in creating an inclusive and accessible learning environment. By prioritizing visual ergonomics, LexAyudha addresses a frequently overlooked yet crucial aspect of dyslexia-friendly design, setting a new standard for educational platforms.

Another pivotal component of the platform is feedback system. This approach not only reads text aloud but also evaluates learners' pronunciation accuracy, providing immediate corrective guidance. This interactive mechanism has been instrumental in improving phonemic awareness and supporting auditory learners, as evidenced by high engagement ratings from participants. The module's ability to transform passive reading into an active, self-corrective process highlights its potential as a core driver of learning and retention. Students who previously struggled with pronunciation and fluency reported increased confidence and motivation, further validating the platform's impact on both cognitive and sensory dimensions of learning.

From a methodological standpoint, the adoption of the Agile Software Development Life Cycle (SDLC) played a crucial role in the platform's development. This iterative approach facilitated rapid prototyping, continuous refinement, and user-centered design, ensuring that the platform remained aligned with the needs of its target audience. Rigorous testing protocols, including unit testing, integration testing, and user acceptance testing, were implemented to validate the platform's robustness and functionality. Experimental results, such as the higher accuracy rate in sentence complexity matching and a improvement in reading accuracy among participants, underscore the platform's effectiveness in delivering meaningful educational outcomes. These findings highlight the importance of an integrated approach that seamlessly combines sensory enhancements, such as chromatic variation, with cognitive scaffolding, such as adaptive content generation and pronunciation feedback. LexAyudha's true strength lies not in any single component but in the synergy between its various features. The seamless convergence of visual, auditory, and linguistic adaptations creates a holistic learning environment that caters to the multifaceted needs of neurodiverse learners. By addressing both cognitive and sensory challenges simultaneously, the platform bridges critical gaps in current educational solutions, offering a comprehensive and personalized approach to learning. From a commercial perspective, LexAyudha holds immense potential for widespread adoption across schools, homes, and educational technology companies. Its modular design, scalable architecture, and data-driven personalization make it a competitive and impactful solution in the EdTech market, capable of meeting the diverse needs of learners globally.

In conclusion, LexAyudha exemplifies the feasibility and effectiveness of building a real-time, AI-driven educational platform for neurodiverse students. Its contributions extend beyond technological innovation to deliver tangible, real-world educational impact, empowering students with dyslexia and dyscalculia to overcome barriers and achieve academic success. By providing a supportive, adaptive, and engaging learning environment, LexAyudha paves the way for a more inclusive and equitable educational landscape. Future iterations of the platform can further expand its scope by incorporating emotion recognition, multilingual support, and advanced data analytics for educators, ensuring that it continues to evolve alongside the needs of its users and the advancements of technology. Through its groundbreaking approach, LexAyudha not only addresses current challenges but also sets a new benchmark for inclusive educational solutions, reaffirming the transformative potential of AI and personalized learning in education.

5. REFERENCES

[1] E. M. H. De Saram, A. A. D. N. Maduranga, G. P. Pathirage, S. A. V. Dewanmini, S. Thelijjagoda, and J. Krishara, *Walipilla: Mobile Based Screening and Refinement System to Identify the Risk of Reading Weaknesses Due to Dyslexia*. 2023. doi: 10.1109/icacta58201.2023.10393657.

[2] "COE - Students with Disabilities." https://nces.ed.gov/programs/coe/indicator/cgg/students-with-disabilities.

[3] Ministry of Education, "Annual School Census Final Report 2022," Ministry of Education, Sri Lanka, Jun. 2024. Accessed: Aug. 16, 2024. [Online]. Available: https://moe.gov.lk/wp-content/uploads/2024/06/07/Annual_School_Census_Final_Report_2022_V3.pdf

[4] British Dyslexia Association, "About dyscalculia - British Dyslexia Association," British Dyslexia Association. https://www.bdadyslexia.org.uk/dyscalculia/how-can-i-identify-dyscalculia

[5] Pinna, B., & Deiana, K. (2018). On the Role of Color in Reading and Comprehension Tasks in Dyslexic Children and Adults. i-Perception, 9(3), 204166951877909. https://doi.org/10.1177/2041669518779098.

[6] British Dyslexia Association, "British Dyslexia Association," British Dyslexia Association. https://www.bdadyslexia.org.uk/.

[7] Raghuram, A., Hunter, D. G., Gowrisankaran, S., & Waber, D. P. (2019). Self-reported visual symptoms in children with developmental dyslexia. Vision Research, 155, 11–16. https://doi.org/10.1016/j.visres.2018.11.007.

[8] Rajapakse, S., Polwattage, D., Guruge, U., Jayathilaka, I., Edirisinghe, T., & Thelijjagoda, S. (2018). ALEXZA: a mobile application for dyslexics utilizing artificial intelligence and machine learning concepts. 2018 3rd International Conference on Information Technology Research (ICITR). https://doi.org/10.1109/icitr.2018.8736130.

[9] J. P. Cardona, C. Velazquez, G. Dominguez, J. Munoz, and F. Alvarez, "Remedial Training with Learning Objects to Reduce Dyslexia in Children," IEEE, Oct. 2019, doi: 10.1109/contie49246.2019.00022.

[10] W. Canfield, "ALEKS: a Web-based intelligent tutoring system," vol. 35, no. 2, pp. 152–158, Jun. 2001.

6. APPENDICES

Appendix A

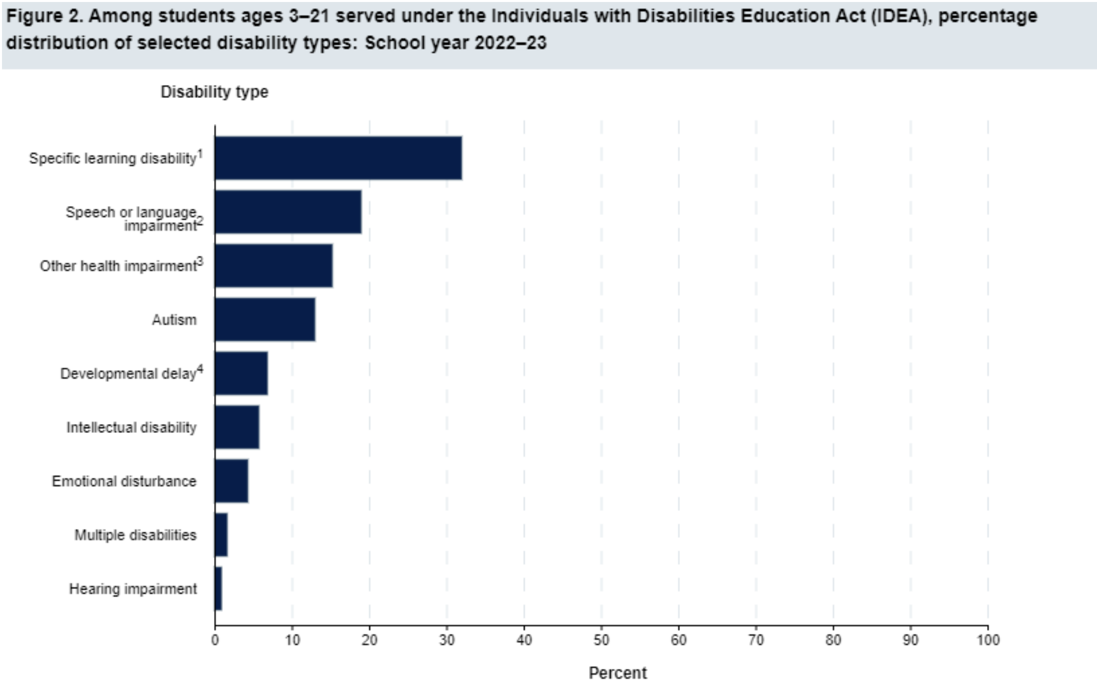


Figure 6.1:Percentage distribution of selected disability types

Source: National Center for Education Statistics – U.S. Department of Education http://nces.ed.gov/programs/coe/indicator/cgg/students-with-disabilities?utm_source=coe_share&utm_medium=figure_tool&utm_campaign=copied_url#2

Grade	Multiple Impairments		Hearing Impairments				Visual Impairments				Speech Language Difficulties		Dyslexia		Interllectual Impairments		Physical Disabilities		Epilepsy		Emotional Problems		Other		Total
			Complete		Half		Complete		Half																
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M
Grade 1	327	202	15	12	41	39	19	6	386	297	454	172	149	81	417	251	145	106	50	27	217	55	100	63	2320
Grade 2	258	170	16	14	58	55	24	11	485	394	410	179	172	86	510	271	148	111	50	36	263	65	84	69	2478
Grade 3	279	169	8	14	68	52	25	15	663	626	358	139	283	141	571	311	159	98	57	33	265	73	100	61	2836
Grade 4	256	135	9	13	80	47	37	13	736	652	304	149	291	141	609	356	173	95	60	34	224	72	97	65	2876
Grade 5	197	166	17	11	59	63	23	23	690	704	230	94	255	148	533	304	139	95	42	42	233	64	87	42	2505
Grade 6	138	108	10	12	88	52	25	15	600	745	155	46	303	133	403	196	127	83	48	30	212	54	92	62	2201
Grade 7	135	58	6	15	71	60	29	14	792	893	158	50	227	113	345	167	117	74	55	30	192	51	78	49	2205
Grade 8	107	59	11	11	60	78	23	16	904	942	128	54	203	68	323	159	120	70	53	39	239	59	71	40	2242
Grade 9	67	46	12	9	63	51	24	18	716	1020	96	44	226	102	294	132	106	77	40	31	184	52	71	35	1899
Grade 10	71	30	6	6	54	41	30	18	636	931	74	32	162	72	198	134	98	77	26	32	184	54	45	32	1584
Grade 11	42	25	12	12	44	36	10	18	613	736	54	29	120	52	170	114	64	74	19	24	135	36	33	23	1316
Grade 11 (Repeaters)	1	2	0	1	2	4	2	0	39	42	5	1	6	3	5	8	5	4	2	0	2	1	3	3	72
Total	1878	1170	122	130	688	578	271	167	7260	7982	2426	989	2397	1140	4378	2403	1401	964	502	358	2350	636	861	544	24534

Source: Annual School Census Data -2019, MoE, Sri Lanka

Figure 6.2: Disability among Students in General Class and Government Schools, Recorded in the Year

Source:https://www.childwomenmin.gov.lk/uploads/common/statistical-hand-book.pdf

Appendix B

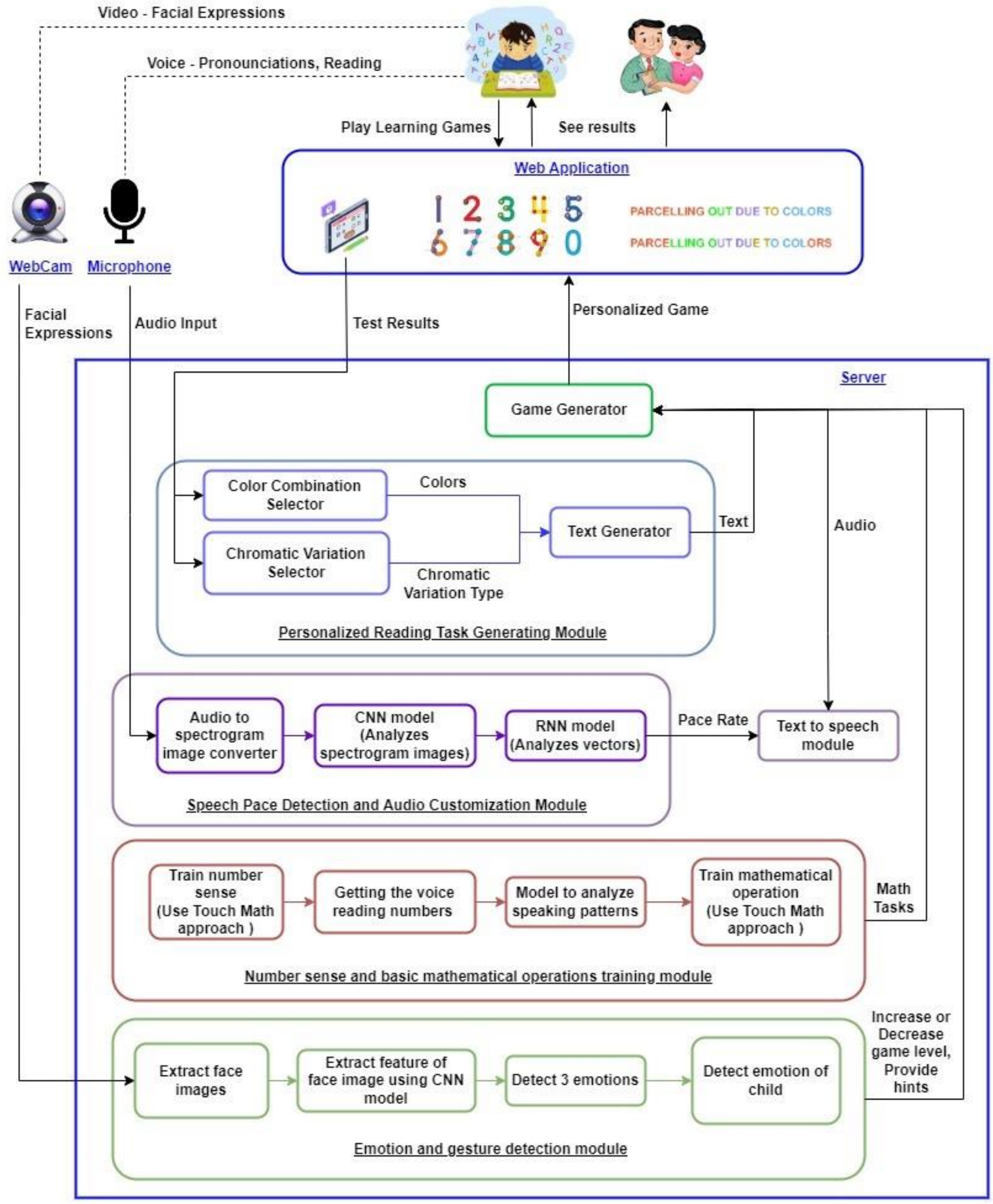


Figure 6.3: System Overview Diagram

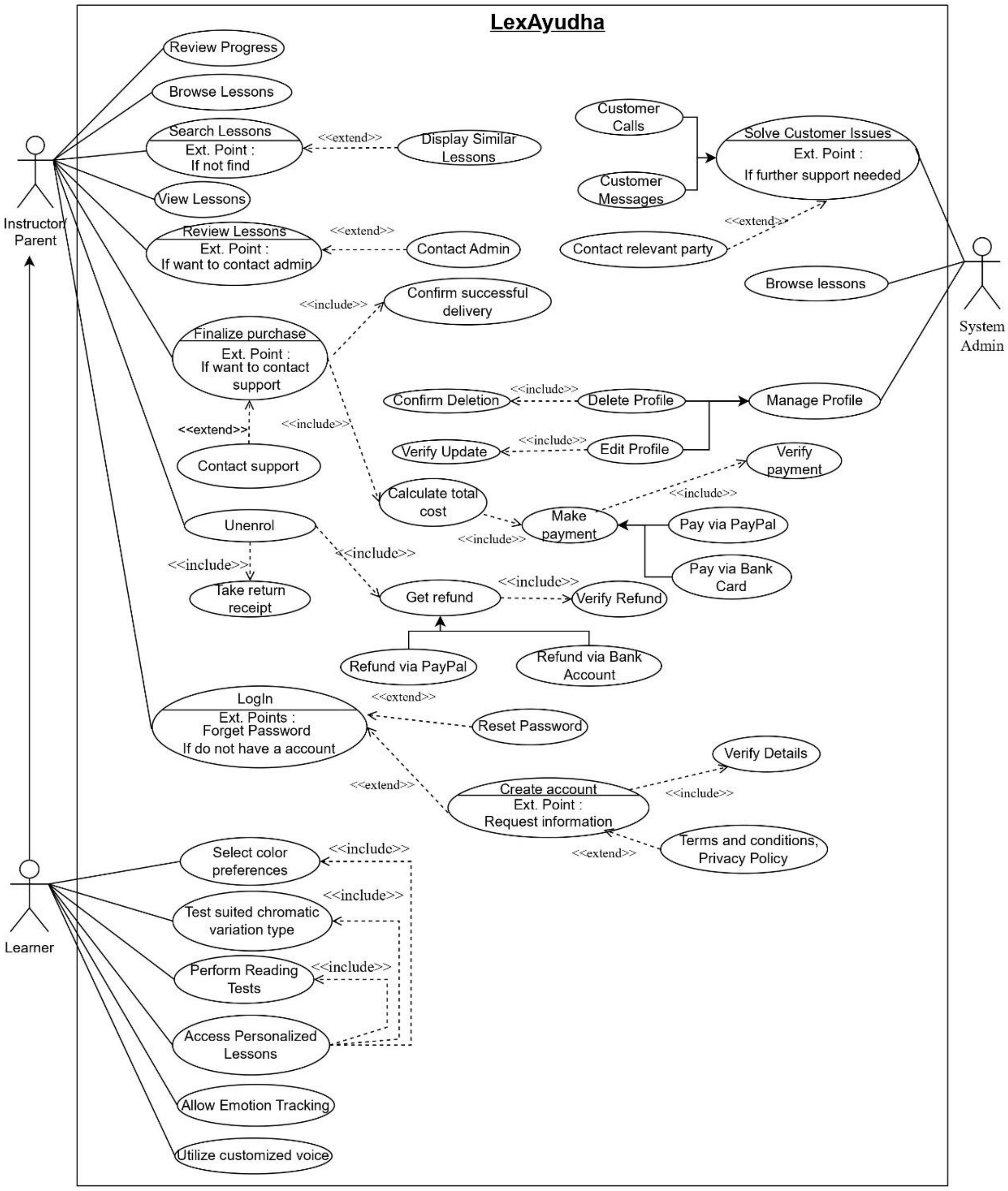


Figure 6.4: Use Case Diagram

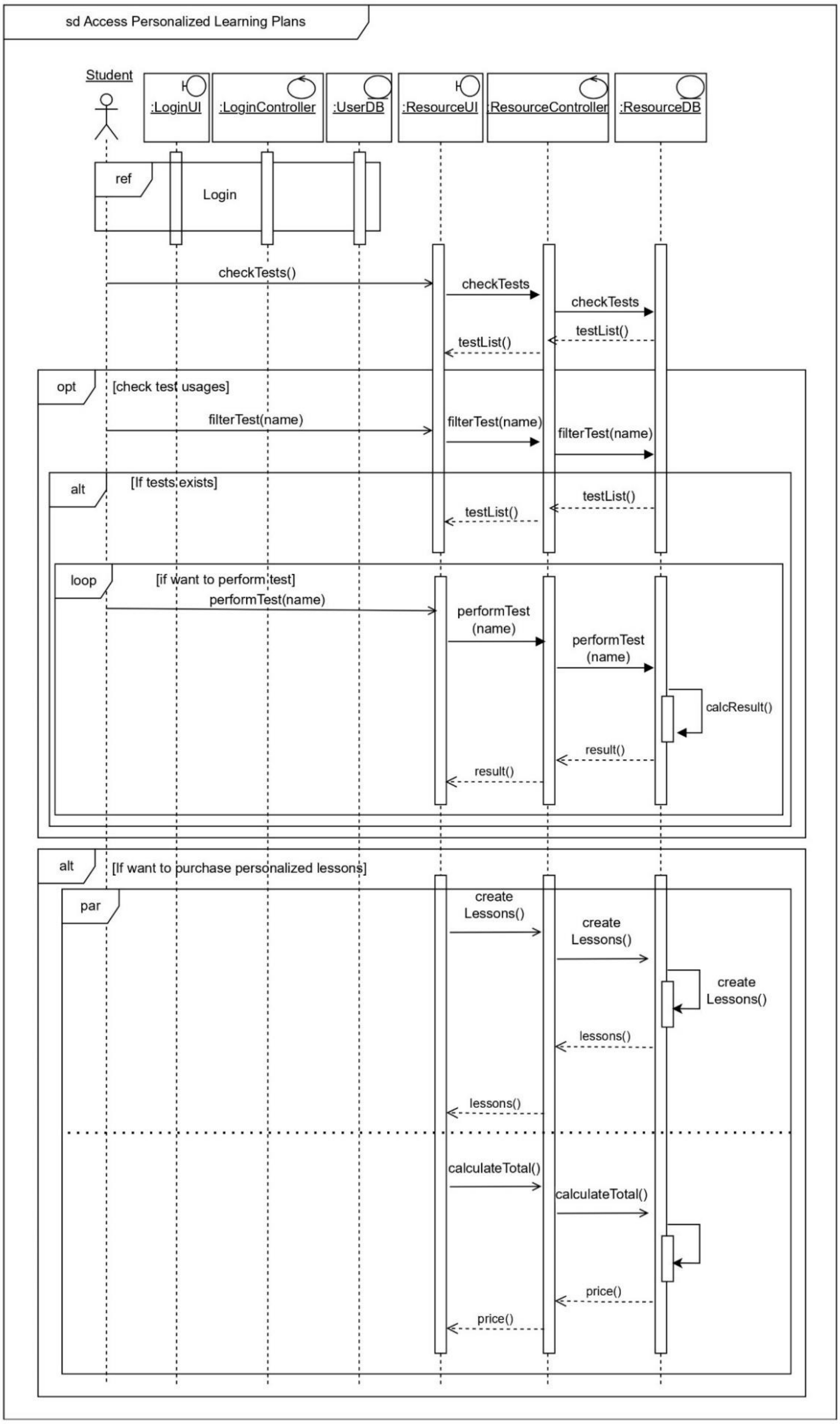


Figure 6.5: Sequence Diagram for Accessing Personalized Learning Plans

Appendix C

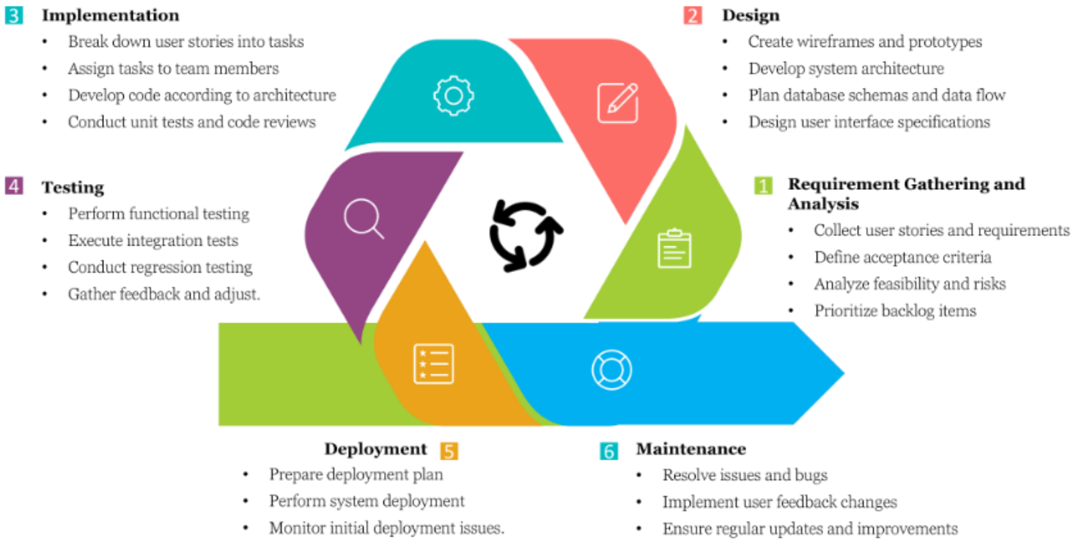


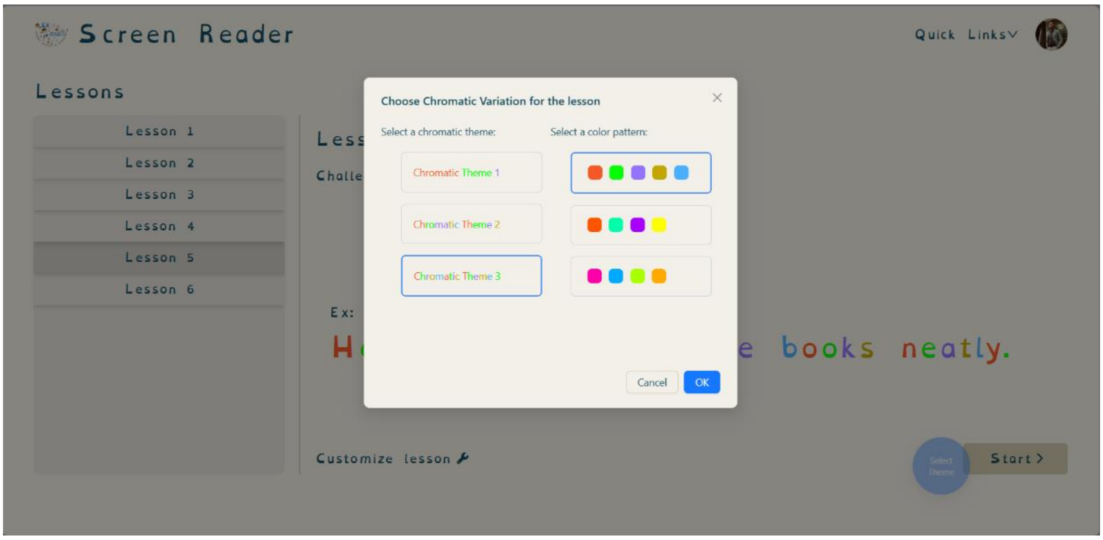
Figure 6.6: Agile Methodology

Appendix D

Figure 6.7: Figma Design

Figma Prototype URL :

https://www.figma.com/design/Ckg8mccpPmfjz2uACpbjkn/Research?node-id=490-164&t=SUp0WheYeHs6mXcX-1



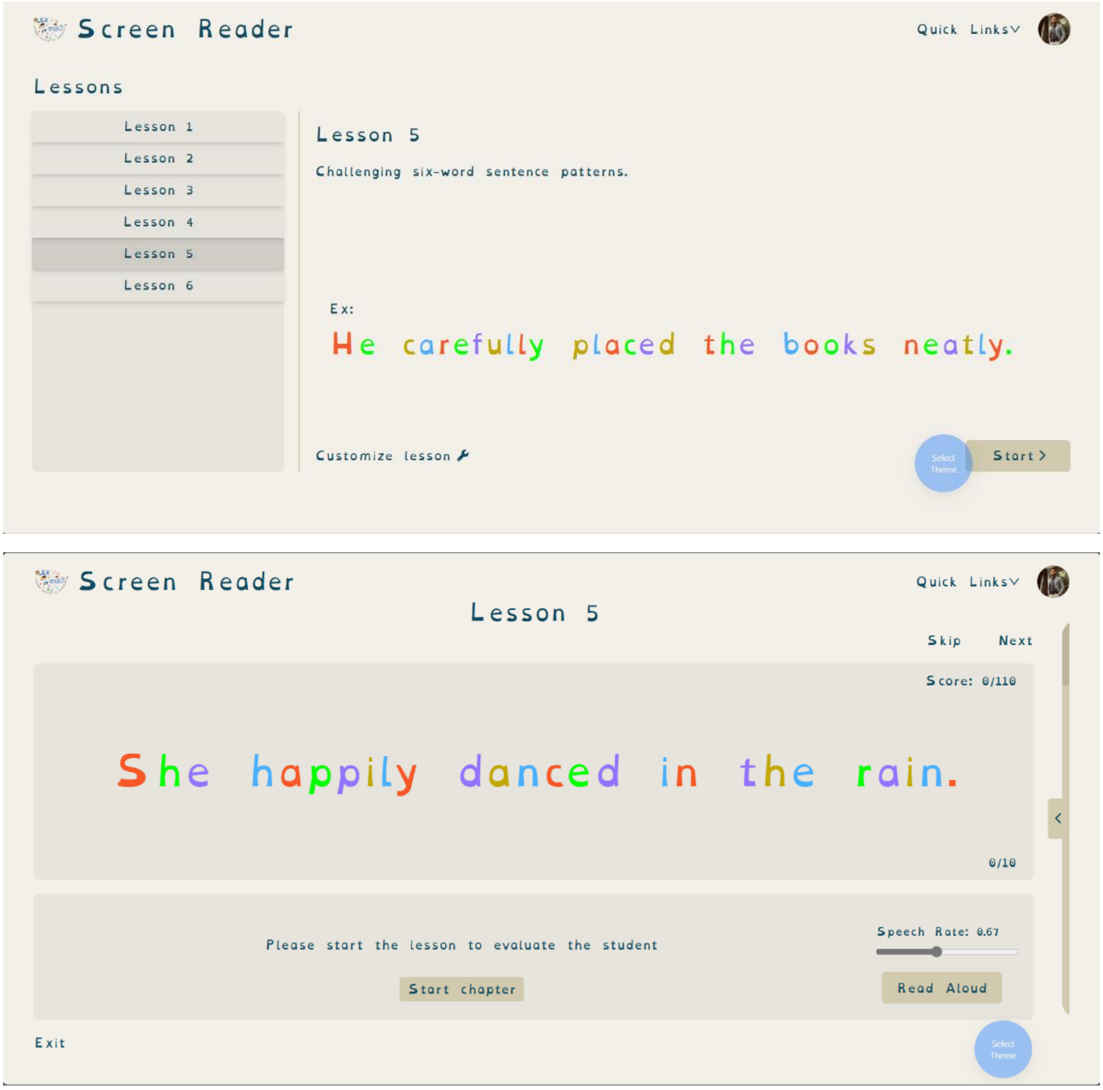


Figure 6.8: Chromatic Variation based User Interfaces

Appendix E

```python
class TextDataset(Dataset):
    def __init__(self, sentences, labels):
        self.sentences = sentences
        self.labels = labels

    def __len__(self):
        return len(self.sentences)

    def __getitem__(self, idx):
        text = self.sentences[idx]
        label = self.labels[idx]
        inputs = tokenizer(text, return_tensors='pt', truncation=True, padding='max_lengt
        return {**inputs, 'labels': torch.tensor(label)}
```

```python
model_name = 'bert-base-uncased'
tokenizer = BertTokenizer.from_pretrained(model_name)
model = BertForSequenceClassification.from_pretrained(model_name, num_labels=2)
```

```python
optimizer = AdamW(model.parameters(), lr=2e-5)
```

Figure 6.9: Sample Code Snippets

Appendix F

Table 6.1: Work Breakdown Structure

Student Name	Student ID	Research Component
Silva T.U.D	IT21318320	1. Create a sample test to identify the efficient color combinations for the child. 2. Create a sample test to identify the most efficient chromatic variation type for the child. 3. Create a test to check the reading skills of the child to customize the complexity levels of the tasks. 4. Create personalized reading task plans for each child.
Madusanka G.K.I	IT21189944	1. Emotion Recognition Algorithm Development 2. Real-Time Adaptive Feedback Loop 3. Personalized Emotional Baseline Establishment

		4. Integration of Emotion Regulation Strategies and provide feedback to educators and parents
Thalangama T.P	IT21223594	1. Implementing a speech pace detection AI model that outputs the pace as a numerical value. 2. Implementing a pace incorporating text to speech (TTS) model.
Dissanayake M.G.T.W	IT21319174	1. Implement Touchpoints on numerals for tactile learning 2. Providing a memorizing approach to improve mathematical skills. 3. Integrates visual, tactile, auditory, and kinesthetic elements.