Software Requirement Specification Document for Nexia Tutor: Adaptive Language Tutoring System for Dyslexic individuals

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April 9, 2024

Table 1: Document version history

Version	Date	Reason for Change
1.0	16-Dec-2023	First version of software specifications are defined.
2.0	09-Apr-2024	Second version of software specifications are defined.

GitHub: https://github.com/amr2006223/Nexia-Tutor.git

Figure 1: QR Code for the GitHub repository.

Contents

Abstract

While individuals are frequently classified as high achievers or low performers, there is a group that is frequently disregarded, their unrealized potential hidden by the label 'learning difficulties'. Despite having above-average IQs, some individuals struggle with reading, writing, listening, and working memory. This marginalized population has lifetime challenges that affect both their health and education. Our holistic approach is designed to empower these individuals specifically in the domain of phonological awareness in the area of language learning, with an emphasis on school quality (80%) and health quality (20%) as a secondary factor. We determine their limitations and preferences through an initial evaluation, directing individuals towards a personalized teaching strategy. To uncover their language potential, this 'tutor companions' uses voice, chat, personalized games, exercises, and approaches adapted to their specific needs.

1 Introduction

1.1 Purpose of this document

The main purpose of this Software Requirements Specifications (SRS) document is to outline the software requirements for 'Nexia Tutor,' our innovative solution. It's a specialized platform for classifying individuals with Dyslexia and creating a tailored language tutoring environment using personalized games, activities, and a user interface tailored to their unique needs. This document serves as a roadmap for developers and a key reference for stakeholders, offering detailed insights into the functional and non-functional requirements essential for a successful system implementation.

1.2 Scope of this document

Our project targets kindergarten students and children with Dyslexia, enhancing reading, spelling and memorization aspects like phonological awareness in new languages through an AI-driven, one-to-one tutoring system. With personalized learning experiences, interactive games, and a tailored interface, our initiative streamlines the learning process, easing the burden on parents and teachers while supporting children's development.

1.3 Business Context

The historical context of dyslexia reveals its late recognition as a specific learning disability, with Rudolf Berlin coining the term 130 years ago [1]. Dyslexia poses challenges for children in academic and social realms, necessitating personalized education plans [2]. However, the gap lies in teacher awareness and the lack of continuity between school and home support [3]. Specific difficulties in phonological awareness further complicate matters [4], requiring dynamic and automated technology interventions [5]. These interventions must be adaptable, user-friendly, and integrated into existing educational practices [6] to effectively address the nature of phonological awareness difficulties, especially in kindergarten-aged children with dyslexia. Successful implementation promises transformative benefits revolutionizing education [7]. Urgent action is

imperative to bridge these gaps and support the unique needs of individuals facing dyslexia-related challenges.

2 Similar Systems

2.1 Academic

Maria Rauscheberger et al. [8], presented “A Universal Screening Tool for Dyslexia by a Web-Game and Machine Learning” tool addressing the diagnosing of dyslexia [9] for children and that it can lead to difficulties like failing school. The authors proposed a solution by measuring the interactions of children, to find differences in their behavior and determine if they are diagnosed with dyslexia. In their machine language model, they used random forest algorithm [10] and extra trees that resulted with different accuracies for different languages for German, Spanish their accuracy was 0.74 and 0.69 respectively also an F1-score of 0.75 for both. However, the accuracy in this paper was found to be enhanced to be 0.89 for English in another research paper [11] that has a similar system.

Serban et al. presented a research titled by "Korbit: A Large-Scale, Open-Domain, Mixed-Interface Dialogue-Based ITS for STEM" [12] introducing an innovative, scalable intelligent tutoring system (ITS) for STEM education. Korbit utilizes machine learning, natural language processing [13], and reinforcement learning [14] for interactive online learning. Its modular design allows teachers to swiftly create new modules. Built on a microservices architecture [15], Korbit’s cloud-based infrastructure can accommodate millions of students. The mixed-interface approach includes videos, dialogue-based exercises, question-answering, diagrams, math exercises, and gamification. Despite its versatility, it is not designed for special education. Figure 2, shows a sample of how Korbit works specially on responding to incorrect solutions.

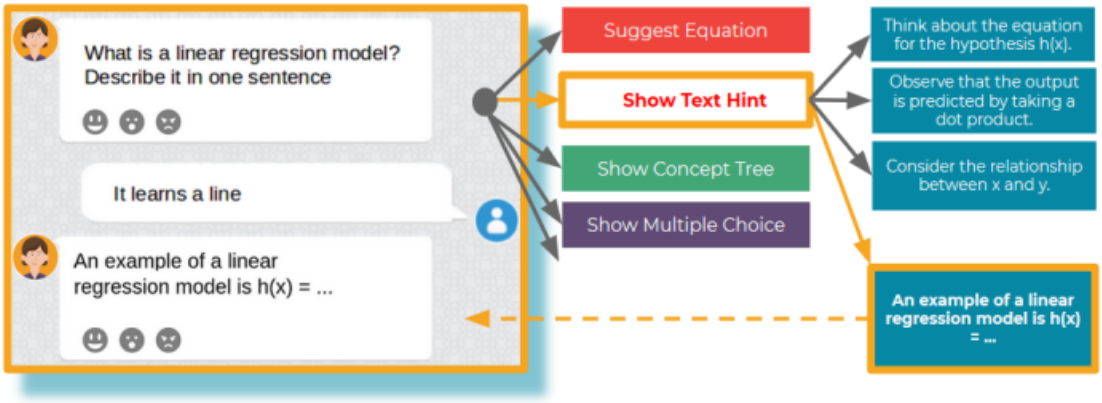


Figure 2: Illustration of Korbit system choosing a pedagogical intervention when the student gives an incorrect solution

Sarthika Dutt, Neelu Jyothi Ahuja and Manoj Kumar [16] presented a research titled by “An intelligent tutoring system architecture based on fuzzy neural network (FNN) [17] for special

education of learning-disabled learners" the authors addressed the problem of children that may feel uneased when going through multiple screening process for identifying learning difficulties specifically Dyslexia, Dyscalculia and Dysgraphia [18]. That's why the authors created an ITS (Intelligent Tutoring system) [19] to identify learning problems by using (FNN) fuzzy neural network and then teaches the student according to their preferences. However, the author didn't provide the dataset and didn't show metrics for the algorithm.

2.2 Business Applications

2.2.1 Synthesis Tutor

Synthesis Tutor is an innovative digital tutoring system developed at Ad Astra on the SpaceX campus, designed to emulate human teaching methods in mathematics, offering continuous availability. The system fosters student growth by encouraging reflection on both successful and challenging decisions made during interactive games. However, the absence of information on data and metrics for evaluating the system's performance poses a limitation. The associated curriculum prioritizes deep understanding and empowerment. Notably, Synthesis Tutor is not specifically tailored for special education students. In Figure 3, observe how Synthesis Tutor creates an interactive learning environment integrating elements such as chat, games, and voice interactions.

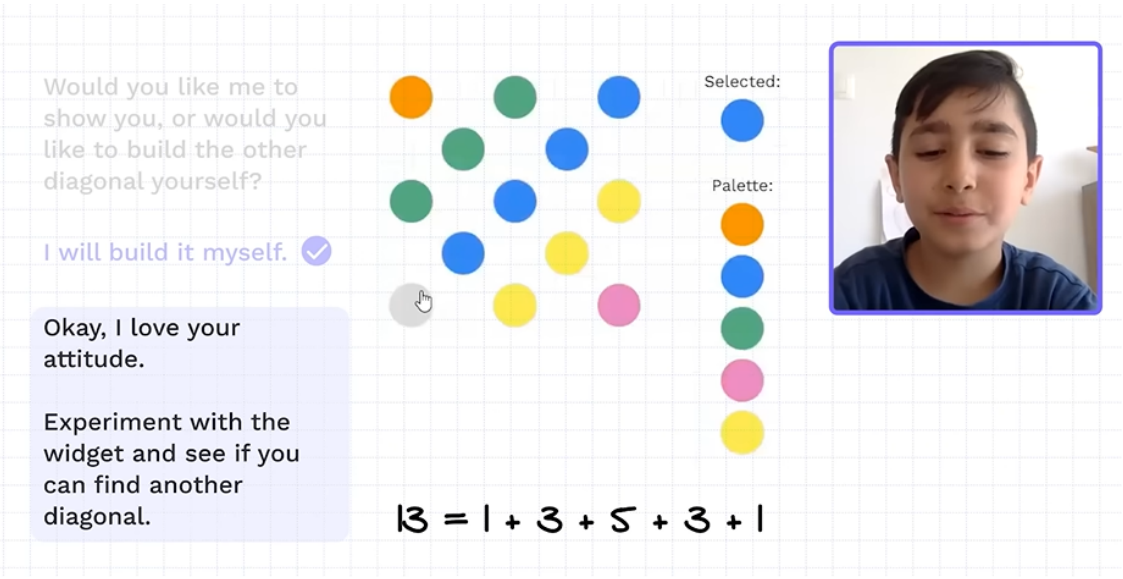


Figure 3: Illustration of Synthesis Tutor generating games and employing innovative teaching methods in Mathematics

3 System Description

3.1 Problem Statement

The primary challenge this project aims to address is the lack of tailored educational interventions for individuals with learning disabilities, specifically focusing on phonological alphabetical awareness in reading disabilities' challenges. Current educational systems often offer generalized support, overlooking the diverse needs of learners with reading disabilities. Additionally, the absence of early and accurate diagnostic tools exacerbates the problem, hindering timely and personalized interventions. Consequently, the project seeks to rectify this gap by providing a comprehensive learning support system that conducts precise assessments, identifies challenges related to reading and working memory, and delivers personalized AI-driven tutoring experiences. The overarching problem is the inadequate provision of specialized educational support, and the proposed project aims to bridge this gap for enhanced learning outcomes and inclusivity.

3.2 System Overview

As depicted in the System Overview provided in Figure 4, the dataset (referenced in Figure 4) serves as the foundation for our analysis. This dataset undergoes a comprehensive pre-processing phase, involving data cleaning, removal of missing values, and data augmentation. Furthermore, categorical data is encoded, and features are extracted from user responses. The process proceeds with k-fold cross-validation, utilizing the random forest algorithm for classification—specifically, a binary classification distinguishing between dyslexic and non-dyslexic cases. Subsequent calculations are performed to identify the specific dyslexia category. Following the classification, a screening test report is generated, and the data from this report is stored in a database for future reference. The tutoring service seamlessly retrieves relevant data from the database to offer personalized recommendations for games, activities, and lessons, ultimately creating a customized learning environment for users. Additionally, there is a potential integration of web scraping techniques to gather content from the web, expanding the range of resources available for personalized learning experiences.

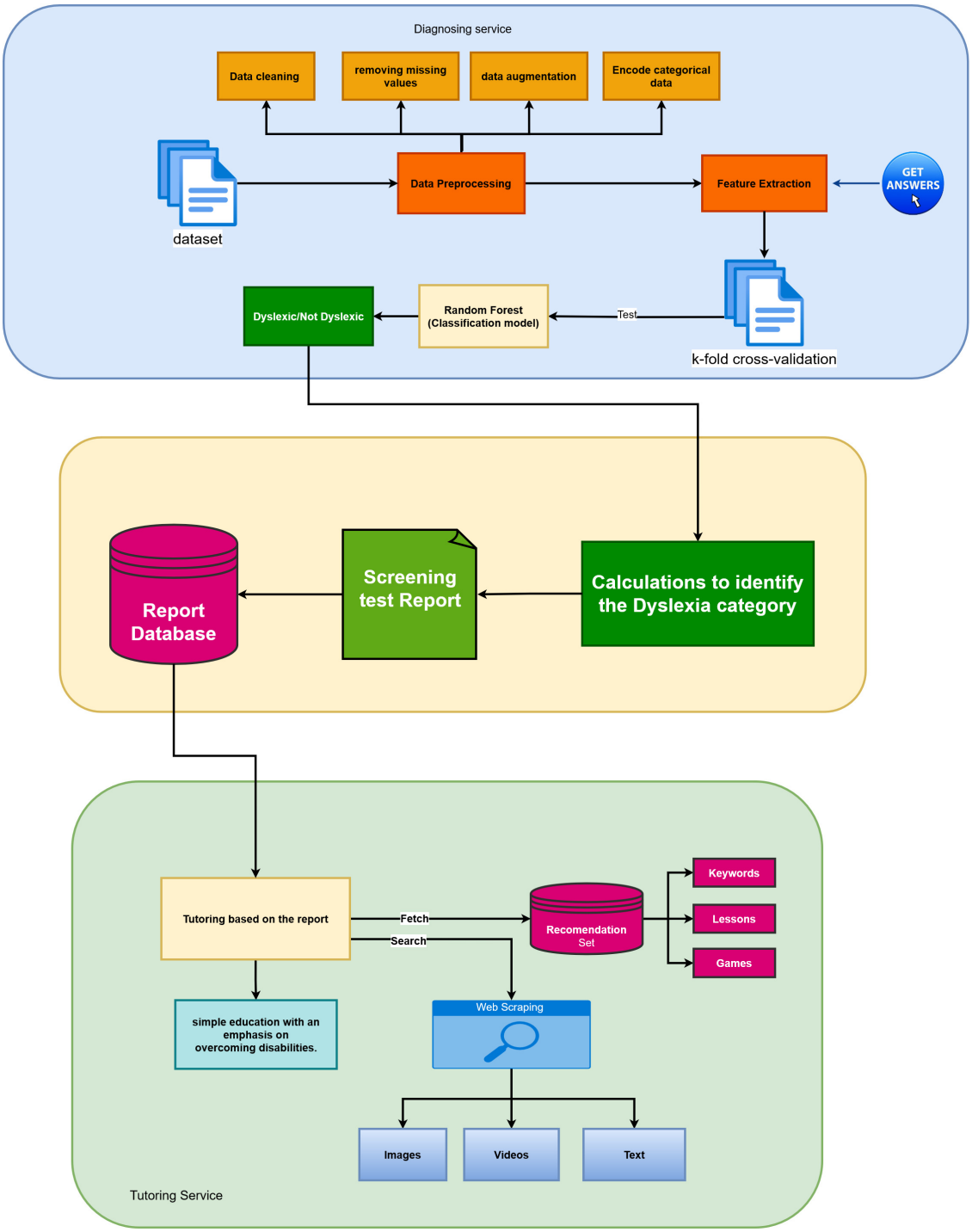


Figure 4: System Overview Diagram

3.3 System Scope

Our project aims to comprehensively address dyslexia challenges and facilitate learning for dyslexic individuals by incorporating the following key features:

- Dyslexia Screening Game
- Comprehensive Difficulty Reports
- Personalized AI Tutoring
- User-Friendly interface for Dyslexia

3.4 System Context

As depicted in Figure 5, our project's context diagram visually outlines the seamless user experience. It elucidates the user's ability to effortlessly log in, undertake the screening test, and receive the corresponding screening test report. Moreover, users can navigate the lessons roadmap, choosing specific lessons tailored to their needs. In return, they gain access to personalized tutoring content, complete with engaging tutoring games curated to enhance their learning experience.

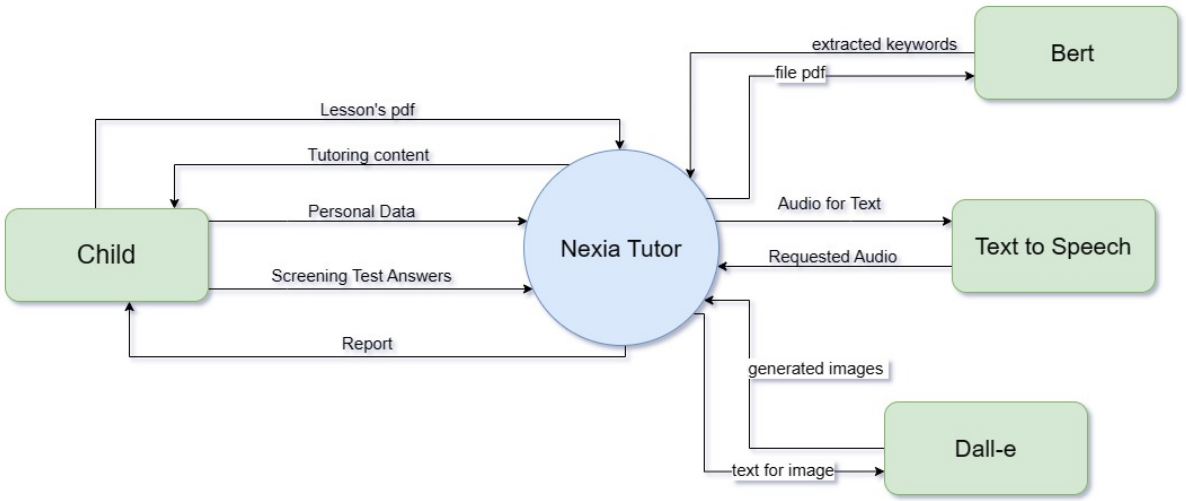


Figure 5: Nexia Tutor Context Diagram

3.5 Objectives

The main objectives of the system are:

- Develop an accessible personalized user interface with tailored fonts and themes for system users.
- Address and classify reading challenges in children, prompting official diagnosis if challenges are identified.
- Generate detailed reports to guide users on actions and strategies for addressing identified challenges.
- Generate personalized games and activities for tutoring sessions based on each child's specific case.
- Allow users to track the child's progress and assess educational efforts efficiently.
- Implement accessibility options for dyslexic children, including text-to-speech, theme, font, and color customization.
- Add search and filters for easy access to lessons, content, and user history.
- Integrate gamification features to motivate and engage children in the learning process.
- Design the system to be easily modifiable and maintainable, allowing seamless addition of new games, activities, or cases in the future.

3.6 User Characteristics

3.6.1 Target Users

- Our primary focus centers on children within the age range of 5 to 10 years old.

3.6.2 Proficiency

- For children in the kindergarten stage unable to use the system independently, parents are responsible for key functionalities such as registration and evaluation. They should actively support and assist the child when necessary.
- The child doesn't need to have prior language knowledge; the system automates language learning based on age and proficiency level.
- The parent or managing user is advised to regularly access the system or monitor email notifications for updates.
- Administrators should be proficient in basic management operations
- Developers must possess a robust software development background to ensure the system's ongoing maintenance and adaptation as required.

4 Functional Requirements

4.1 System Functions

As shown in Figure 2. The use case diagram illustrates key interactions within the system. Users can initiate a screening test, view reports, and choose content for learning. The system classifies user scores and extracts main keywords to facilitate content selection. The learning process is initiated once the user has chosen relevant content. The diagram provides a visual representation of the functional relationships among different system components.

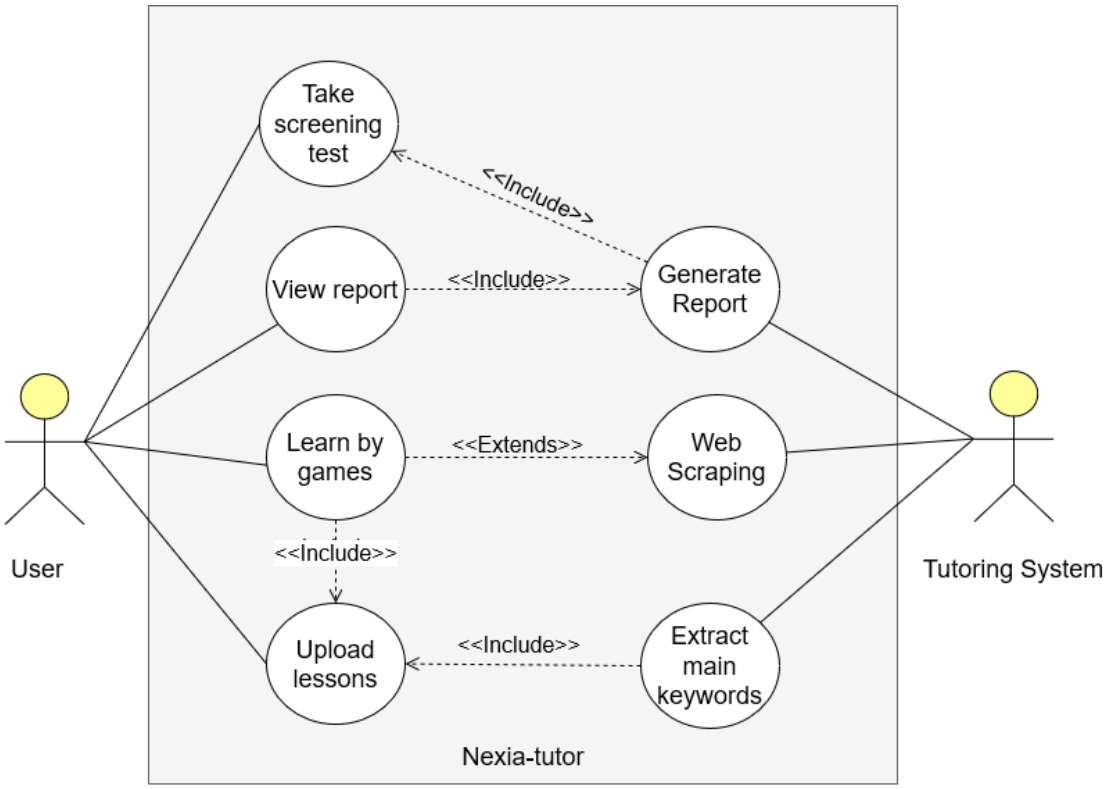


Figure 6: Use Case Diagram for Nexia Tutor

System Functions:

- The user shall be able to Login as a prerequisite before accessing system functionalities
- The user shall be able to participate in the screening test, after login
- The user shall be able to view the classified screening test results, following the screening test
- The user shall be able to view report summarizing the screening test results, following the screening test
- The user shall be able to choose personalized educational content to support learning
- The user shall be able to launch lessons through an internal service that automates the extraction of main keywords from selected content, thus preparing it for tutoring
- The user shall be able to engage in learning lessons tailored to their specific needs using personalized games and activities

4.2 Detailed Functional Specification

Table 2: Dyslexia Classification Function

Name	**Predict Dyslexia for user**
ID	F01
Priority	High
Description	Classify dyslexia based on a given dataset and specific sub-type of dyslexia
Input	Record of user answers as string
Action	Login and take the screening test
Output	User has dyslexia or not and dyslexia subtype
Pre-condition	User takes the test
Post-condition	-
Dependencies	-
Risk	Inaccurate data from user/Internet connection required

Table 3: Case Reporting Function

Name	**Generate Report for user**
ID	F02
Priority	High
Description	Generate a report for the user for more clarification on their test results
Input	Record of user answers as string
Output	Detailed report for the user
Action	After taking the screening test, choose to generate a report
Pre-condition	User takes the test
Post-condition	-
Dependencies	F01
Risk	Internet connection required

Table 4: Lesson Selection Function

Name	**getGamesForLesson**
ID	03
Priority	High
Description	The function retrieves a lesson, and maps games based on the user's difficulty type for a personalized learning experience
Input	Lesson name, user ID
Action	Select the lesson based on the content level roadmap
Output	Json structure with dyslexia types and lesson details
Pre-condition	Screening test, user should have a difficulty to be addressed
Post-condition	Use the content and games
Dependency	F01
Risk	User doesn't have problems to be addressed/Internet connection required

Table 5: Lesson Selection Function

Name	**getLessonKeywords**
ID	04
Priority	High
Description	The function retrieves the keywords based on the selected lesson,experience
Input	Lesson name
Action	Select the lesson based on the content level roadmap
Output	Json structure with lesson keywords
Pre-condition	Screening test, user should have a difficulty to be addressed
Post-condition	Use the content and games
Dependency	F03
Risk	User doesn't have problems to be addressed/Internet connection required

5 Design Constraints

5.1 Standard Compliance

Ensure the system's adherence to responsive web design principles, providing a seamless experience across devices.

5.2 Accessibility Constraints

Implement features and design elements that adhere to accessibility standards, prioritizing inclusivity for dyslexic children and individuals with diverse needs such as Providing dyslexia-friendly fonts, font size, and spacing

5.3 Device Compatibility

Optimize the system for compatibility with prevalent devices, including smartphones and tablets, ensuring widespread accessibility.

5.4 Data Privacy Compliance

Incorporate robust measures for data privacy compliance, safeguarding sensitive user information such as Encrypting sensitive user information during data transmission and upholding confidentiality to build and maintain user trust.

5.5 Scalability

Design the system to be scalable, accommodating future updates, additional features, and an expanding user base without compromising performance, an example practice is Adopting a microservices architecture to decouple components and allow independent scaling.

5.6 Other Constraints As Appropriate

Require internet access for users to utilize the system, ensuring connectivity for effective utilization

6 Non-functional Requirements

- **Usability:**
  Requirement: The system must have a user-friendly interface.
  Reason: To facilitate easy interaction for dyslexic individuals, promoting a positive user experience.

- **Accessability:**
  Requirement: The system must adhere to accessibility standards.
  Reason: Ensure inclusive design, accommodating diverse dyslexic needs.

- **Response Time:**
  Requirement: The system must have low response times.
  Reason: To Enhance engagement and minimize frustration, especially for dyslexic users requiring prompt feedback and responsiveness.

- **Availability:**
  Requirement: The system must be available 24/7.
  Reason: To ensure constant access for dyslexic individuals with varied schedules

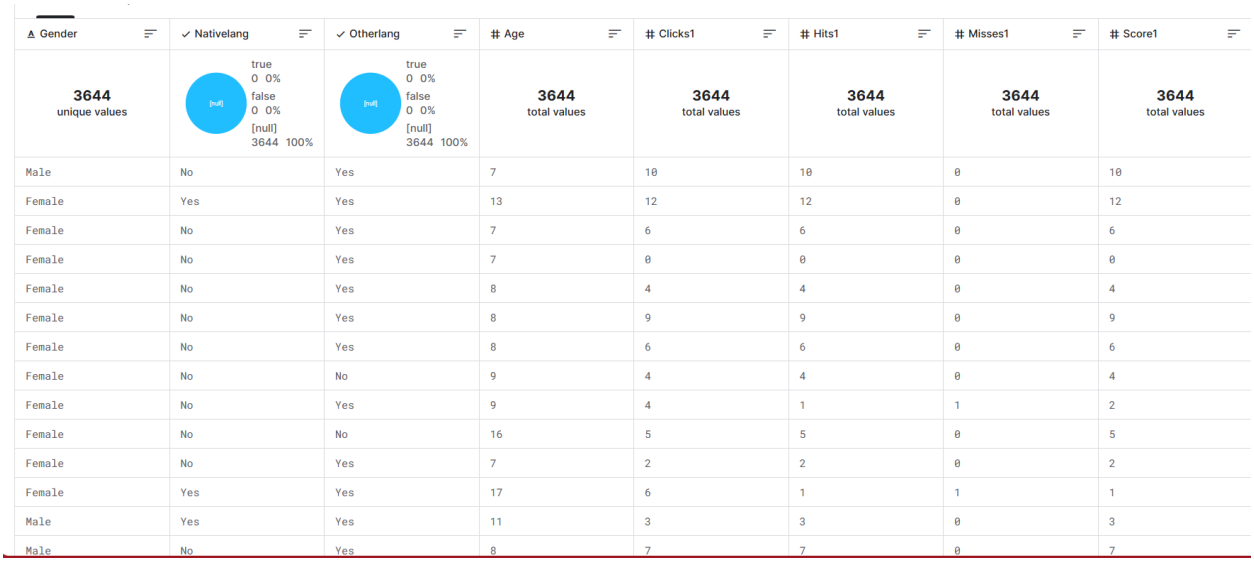
- **Performance:**
  Requirement: The system must deliver optimal performance, with minimal latency.
  Reason: To provide a responsive learning experience, addressing the challenges faced by dyslexic users.

- **Maintainability:**
  Requirement: The system should be easily maintainable.
  Reason: To ensure that the system is adaptable to future needs, and capable of incorporating new features.

7 Data Design

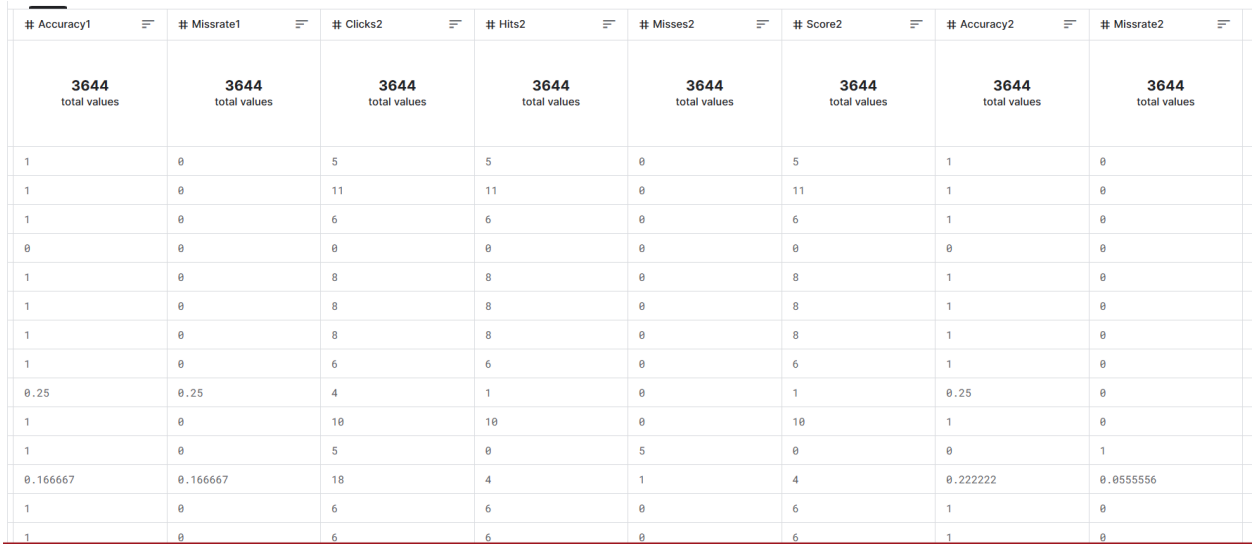
7.1 Dataset used in the Screening Service

The dataset [20] in Figure 7 originates from a predictive Spanish machine learning online game designed for dyslexia screening [21], utilizing binary classification. It encompasses over 3,644 participants who engaged in 32 linguistic exercises specifically crafted for integration into a web-based gamified test. Each set of questions in the dataset classifies a distinct area of difficulty, aligning with the categorization proposed by the authors in Article (3), even though the overall label is binary we have made calculations employed to subdivide the dataset features into subtypes.



Gender	Nativelang	Otherlang	Age	Clicks1	Hits1	Misses1	Score1
3644 unique values	true 0 0% false 0 0% [null] 3644 100%	true 0 0% false 0 0% [null] 3644 100%	3644 total values	3644 total values	3644 total values	3644 total values	3644 total values
Male	No	Yes	7	10	10	0	10
Female	Yes	Yes	13	12	12	0	12
Female	No	Yes	7	6	6	0	6
Female	No	Yes	7	0	0	0	0
Female	No	Yes	8	4	4	0	4
Female	No	Yes	8	9	9	0	9
Female	No	Yes	8	6	6	0	6
Female	No	No	9	4	4	0	4
Female	No	Yes	9	4	1	1	2
Female	No	No	16	5	5	0	5
Female	No	Yes	7	2	2	0	2
Female	Yes	Yes	17	6	1	1	1
Male	Yes	Yes	11	3	3	0	3
Male	No	Yes	8	7	7	0	7

Figure 7: characteristic features



Accuracy1	Missrate1	Clicks2	Hits2	Misses2	Score2	Accuracy2	Missrate2
3644 total values	3644 total values	3644 total values	3644 total values	3644 total values	3644 total values	3644 total values	3644 total values
1	0	5	5	0	5	1	0
1	0	11	11	0	11	1	0
1	0	6	6	0	6	1	0
0	0	0	0	0	0	0	0
1	0	8	8	0	8	1	0
1	0	8	8	0	8	1	0
1	0	8	8	0	8	1	0
1	0	6	6	0	6	1	0
0.25	0.25	4	1	0	1	0.25	0
1	0	10	10	0	10	1	0
1	0	5	0	5	0	0	1
0.166667	0.166667	18	4	1	4	0.222222	0.0555556
1	0	6	6	0	6	1	0
1	0	6	6	0	6	1	0

Figure 8: exercises features

7.2 Databases

Figure **??**, shows the ERD diagram for our Database and how the relationships will be formed

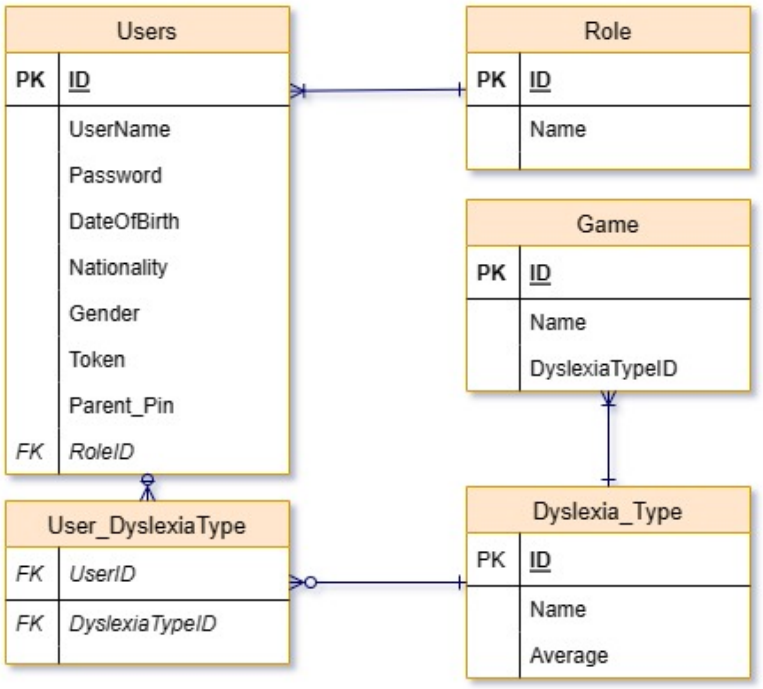


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Figure 9: Database schema diagram

8 Preliminary Object-Oriented Domain Analysis

Initial Class Diagram

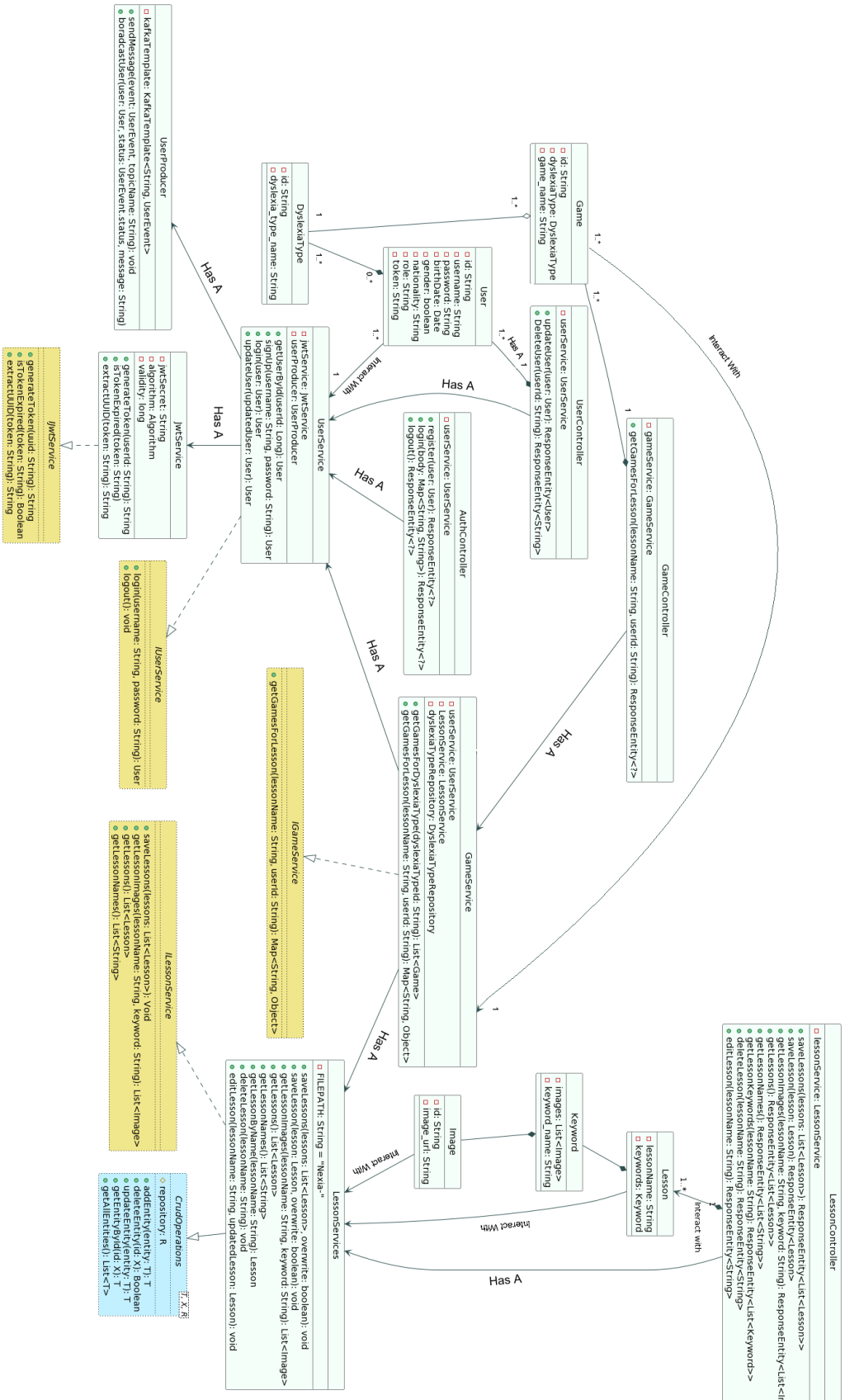

Figure 10: Nexia's UML diagram

9 Operational Scenarios

9.1 Scenario 1:

The user as in figure 1 starts by logging in to access the dyslexia screening service. He completes the screening test, and the system classifies the scores, providing insights into his dyslexia profile.

9.2 Scenario 2:

After taking the screening test as in figure 1, the user views a detailed report summarizing his dyslexia screening results. The report includes personalized guides and recommendations on addressing specific challenges.

9.3 Scenario 3:

As shown in figure 10 , the user navigates to the content selection feature to choose educational material tailored to his needs, and the system extracts main keywords to prepare the content for tutoring.

9.4 Scenario 4:

The user as in figure 9, having selected content, engages in the tutoring service by learning lessons based on their specific case, utilizing interactive games and activities designed to enhance his learning experience.

9.5 Scenario 5:

The user accesses the evaluation dashboard to track his progress, view personalized learning insights, and evaluate his efforts in overcoming dyslexia educational challenges.

9.6 Scenario 6:

In this scenario, the user explores gamification elements, progress tracking, the roadmap for their learning journey, and personalized insights in the "My Learning" section. This comprehensive scenario encapsulates various interactive and informative aspects of the system.

10 Project Plan

From Proposal to SDD.

GANTT CHART FOR NEXIA TUTOR

Nexia Tutor (dyslexia intelligent tutor)
PROJECT NAME

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TEAM

Task ID	Task Name	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July
T01	Browsing Datasets												
T02	Writing Project Proposal												
T03	Preprocessing Dataset												
T04	Establishing Database and Database Design												
T05	Implementing screening API												
T06	Implementing intervention tutoring API sample												
T07	Interface Research and Design (UI & UX)												
T08	Writing SRS												
T09	Developing the FrontEnd side												
T10	Implementing the Tutoring service API using AI												
T11	Implementing intervention features (text-to-speech, scrapping, etc.)												
T12	Writing SDD												
T13	Testing The Project												
T14	Writing Research paper												
T15	Writing the Final Thesis												
T16	Deploying the Project and making it accessible to users												

Figure 11: Gantt Chart for The Project Plan

11 Appendices

11.1 Definitions, Acronyms, Abbreviations

Table 6: Definitions, Acronyms, Abbreviations

SRS	Software Requirement Specification
AI	Artificial Intelligence

11.2 Supportive Documents

11.2.1 Contacting Psychologists And Professionals

- **Dr. Noha Yousry - Egypt**

  In a remote meeting with Dr. Noha Yosry, changes in diagnosing learning disabilities outlined in the DSM-5 were discussed, emphasizing the interconnected nature of learning challenges. Three main categories were identified: learning difficulties, learning disabilities, and slow learning. Dr. Noha provided insights, learning resources, and contacts for professionals in Egypt specializing in learning disabilities.

- **Dr. Choy from Altuz Academy - Malaysia**

  - Recorded Meeting Link: Meeting with Dr. Choy Su-Ling - Altuz Academy On 29 Aug. 2023

  The virtual meeting with Dr. Choy covered key aspects, including resource recommendations, framing the assessment service, integrating a learning mechanism into the AI model, and testing the system with Altuz Academy students. Crucial recommendations shaped the direction of the project.

- **Dr. Hassan Salah, CEO of Maharat Learning Center - Egypt** On 26 Aug. 2023, Dr. Hassan shared insights into Maharat Learning Center's approach to learning disabilities. He sponsored access to a valuable online course, provided contacts, and enriched our understanding and resources for addressing learning disabilities in our project.

- **Dr. Abdel Mawgod from Arab Testing - Egypt** On 27 Sep. 2023, Dr. Abdel Mawgod provided valuable suggestions, recommending a unified language for the system and tutoring service in Arabic. Strategic decisions were refined to enhance adaptability, catering to diverse needs. His insights significantly contributed to the project strategy.

- **Dr. Gad ElBeheri, CEO of LightHouse Center - Egypt** During a face-to-face meeting On Sep. 30th, Dr. Gad ElBeheri introduced a personalized online screening test for Dyslexia in Arabic individuals. The test, a paid service, generates comprehensive reports and stands out as the sole Arabic diagnostic test designed specifically for Dyslexia. Dr. Gad ElBeheri's contribution is highlighted in providing a culturally relevant screening tool.

11.2.2 Users and Surveys

- Based on a survey conducted by Dyslexia Advantage organization at United States with more than 4600 responses from dyslexic children at public and private schools

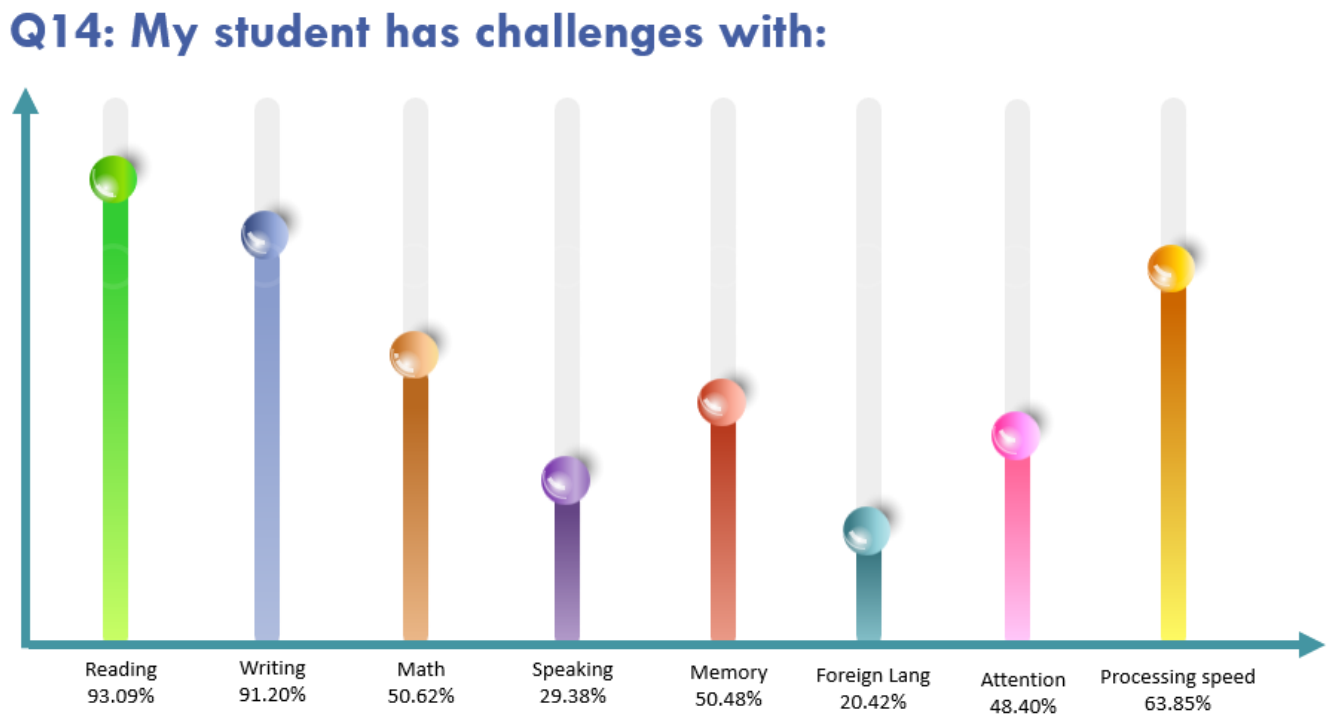

Figure 12: Areas of Challenges students with dyslexia face

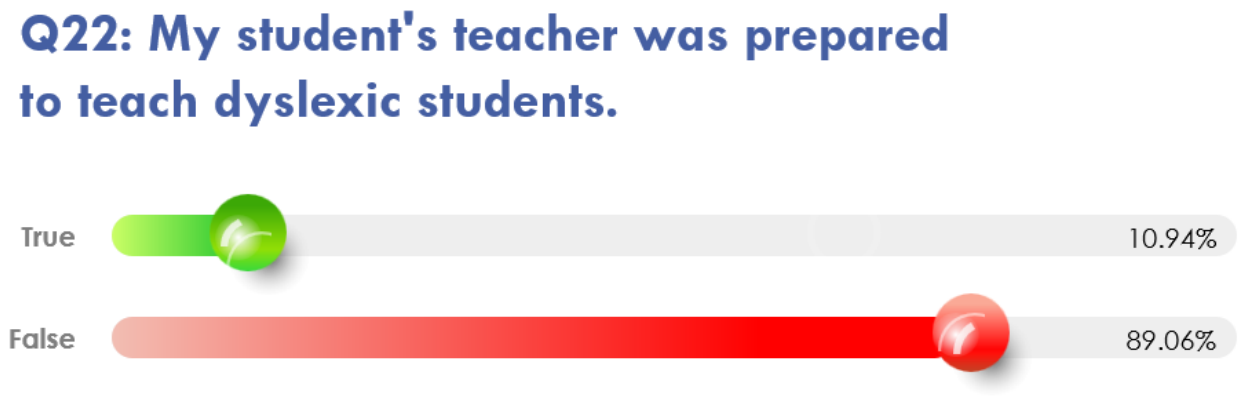

Figure 13: Teacher Preparedness and Awareness in Instructing Dyslexic Students

Figure 14: People's Awareness About Dyslexia

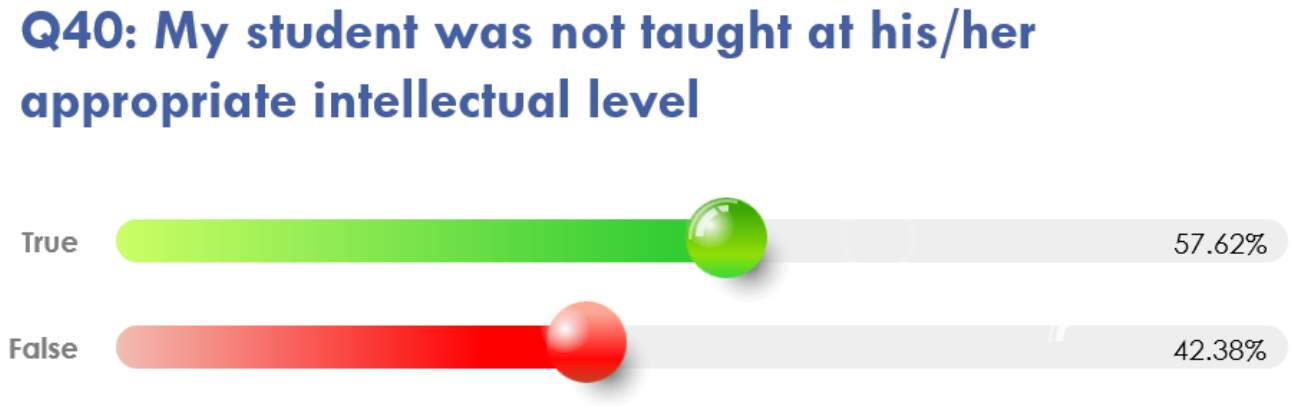

Figure 15: Levels of Dyslexic individuals

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