PRESIDENCY UNIVERSITY
Private University Estd. in Karnataka State by Act No. 41 of 2013
Itgalpura, Rajankunte, Yelahanka, Bengaluru – 560064

COMPUTERIZED COGNITIVE RETRAINING PROGRAM FOR HOME TRAINING OF CHILDREN WITH DISSABILITIES

A PROJECT REPORT

Submitted by

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BACHELOR OF TECHNOLOGY

IN

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PRESIDENCY SCHOOL OF COMPUTER SCIENCE AND ENGINEERING

BONAFIDE CERTIFICATE

Certified that this report "COMPUTERIZED COGNITIVE RETRAINING PROGRAM FOR HOME TRAINING OF CHILDREN WITH DISABILITIES" is a bonafide work of "SRINIDHI B A(20221CSE0341), RUCHITH K (20221CSE00132), THANUSHREE K B(20221CSE0343)", who have successfully carried out the project work and submitted the report for partial fulfilment of the requirements for the award of the degree of BACHELOR OF TECHNOLOGY in COMPUTER SCIENCE ENGINEERING during 2025-26.

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DECLARATION

We the students of final year B.Tech in COMPUTER SCIENCE ENGINEERING at Presidency University, Bengaluru, named Srinidhi B A, Ruchith K, Thanushree K B, hereby declare that the project work titled **"Computerized cognitive retraining program for home training of children with dissabilities"** has been independently carried out by us and submitted in partial fulfillment for the award of the degree of B.Tech in COMPUTER SCIENCE ENGINEERING during the academic year of 2025-26. Further, the matter embodied in the project has not been submitted previously by anybody for the award of any Degree or Diploma to any other institution.

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Abstract

The development of digital therapies has been growing incredibly fast due to the increasing demand for digital support through cognitive interventions, particularly for children with both learning and developmental disabilities. Cognitive intervention requires a lot of hands-on practice and usually takes place through face-to-face meetings between therapists and clients or family members of the client. The cost and time that goes into scheduling these appointments and the logistical challenges associated with getting your child to those appointments make this method a very challenging option for many parents and schools to utilize to help their children grow. At the same time, the introduction of things like AI, gamified learning, and adaptive assessments has provided a unique resource for users to be able to effectively deliver their clients with individualized, digital cognitive rehabilitation exercises. Unfortunately, there are many existing digital rehabilitation solutions that have not developed an adaptive difficulty feature, a way to reinforce positive progress, or a way to monitor clients' progress. This lack of adaptive aspects to digital rehabilitation platforms leads to less engagement from clients and limited effectiveness. The initiative, entitled Computerised Cognitive Retraining App for Children with Disabilities, proposes to fill the existing gaps by incorporating an intuitive and age-appropriate child interface along with a sophisticated progress tracking system and therapist feedback. The app is a mobile and web-based app, allowing children the ability to play cognitive games which target improving memory, attention, reasoning and processing abilities. When children are having difficulty or demonstrating difficulty with a task, the app will automatically adjust the level of difficulty and track the child's performance. Performance logs are kept in an encrypted database and made available to therapists, teachers and parents via a dashboard, providing the ability to monitor performance, provide individualised recommendations and plan for interventions. The app provides timely feedback, incorporates motivational features and includes performance data to maximise transparency, engagement and continuity while minimising the likelihood of developmental needs going unaddressed. This project has been developed using a methodology known as Agile Scrum. Each module

was developed iteratively, focusing on aspect Vs such as gamified cognitive task interface, adaptive scoring engine, analytics dashboard and accessibility support. The front end of the project was developed using Next.js for high performance, Tailwind CSS for responsive and

inclusive UI design, and TypeScript to provide safer coding practices. The project's back end service was developed using Node.js and user authentication, secure storage of data, and cloud synchronization were handled by Firebase. Other supporting tools such as Postman for testing, GitHub for collaborative version control and Vercel for deployment ensured an efficient and effective implementation of the project through teamwork. Through extensive testing including usability evaluation, accessibility compliance testing, functional validation and performance testing, it has been shown that the app increased engagement and the rate at which children complete tasks. The adaptive system also reduced frustration levels and enabled children to consistently participate, so no learner is left unsupported. Risk assessment identified concerns such as device access and data privacy; these risks were addressed through the incorporation of offline modes and secure authentication and by adhering to child-safe data handling standards. The Computerised Cognitive Retraining App aims to enhance cognitive training, skills and recovery for children with disabilities through computerised methods. The application is designed to create an individualised cognitive retrieval strategy based upon an individual's needs, and includes a data-driven approach to track progress and modify individualised cognitive retrieval programs over time. The application will allow for greater access to reduction in the cost of cognitive rehabilitation programs for children with disabilities than current methods allow for. Ultimately, the Computerised Cognitive Retraining App offers support to children with disabilities by integrating many forms of technology into an accessible intervention that meets the unique needs of all learners. This program will create opportunities for these children to receive cognitive support where they might otherwise not be able to access or participate in traditional rehabilitation programs, enabling them to develop the tools necessary to reach their full potential and effectively integrate with their community. The Computerised Cognitive Retraining App is a significant step toward providing evidence- based interventions to support the cognitive recovery and rehabilitation of children with disabilities.

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Abbreviations

Abbreviation	Full Form
AI	Artificial Intelligence Analysis of Variance
ANOVA	Application Programming Interface Annual
API	Status of Education Report Digital
ASER	Infrastructure for Knowledge Sharing
DIKSHA	ECMAScript 6 HyperText Markup Language
ES6	5 Information and Communication
HTML5	Technology JavaScript Object Notation
ICT	Learning Management System Machine
JSON	Learning Massive Open Online Courses
LMS ML	National Education Policy 2020 Natural
MOOCs	Language Processing Representational State
NEP	Transfer Sustainable Development Goal
2020	Transport Layer Security Test Points 1 to 5
NLP	User Interface Virtual CPU Virtual Private
REST	Server Extended Reality
SDG TLS	

Chapter 1
Introduction

1. Background

The cognitive development of children is a critical factor affecting their ability to learn, form social relationships and foster emotional health and wellness. Children with learning disabilities, developmental delays, neurological disorders, attention deficit hyperactivity disorder (ADHD), autism spectrum disorder (ASD) or cognitive processing problems often encounter difficulties related to memory, attention, problems with reasoning and problem- solving as well. In the past, conventional cognitive retraining methods involved one-on-one sessions with a trained therapist, paper and pencil exercises, or scheduled appointments with practitioners, which create a number of obstacles that contribute to a limited ability to access training on an ongoing basis, erratic opportunities to practice, high cost of treatment and inability to monitor progress continually after discharge from the therapist's office.

With the evolution of technology, the increasing use of digital platforms has provided a viable alternative to traditional cognitive retraining. Children are now able to complete interactive cognitive rehabilitation activities via the internet. By using these tools, children may experience higher levels of engagement, more opportunities to build memory through repetition-based learning and the ability to complete therapeutic activities remotely. However, several currently available cognitive rehabilitation software solutions do not have the ability to provide adjusted levels of difficulty and/or provide a personalized path for child-to-child progression through different phases of learning. Additionally, these software solutions do not have the components of gamifying a child's motivation to do cognitive rehabilitation and do not contain established ways to provide structured reporting of a child's progress to their parents, teachers and/or therapists. All of these limitations result in a reduced likelihood of continued engagement and an inability to achieve optimal levels of developmental outcomes.

A Computerized Cognitive Retraining Application for disabled children has been developed to fill this void. This application allows children with disabilities to participate in cognitive retraining, to improve their cognitive skills on an ongoing basis, at home, at school and at a therapy centre. The application consists of gamified task modules, real-time performance monitoring and generating progress dashboards, and personalised recommendations for children with disabilities. Using modern web technologies, including Next.js, Tailwind CSS and TypeScript, the application provides responsive design, ease of use and scalability across multiple devices..

2. Problem Statement

Children with cognitive disabilities often face many barriers in obtaining ongoing and effective cognitive retraining. The main barriers are:

- Limited availability of therapy options - due to costs, distances, and availability specialists, most children do not have access to regular in-person therapy therapy sessions.

•No levels of individual difficulty - children with cognitive disabilities all have different developmental requirements. Therefore, if all children do the same level of exercise, the results are almost never going to be satisfying or rewarding for any child.

•No measurable improvement - Parents and educators cannot measure progress or identify when children are having problems.

•No ability to remotely monitor - At present time, therapists cannot see how often a child is doing practice exercises outside of the scheduled sessions.

The proposed system is designed to be a cognitive-training application for children. This application contains exercises that adapt to the child's ability, provides gamification to keep children interested in the exercises, and provides a structured method of monitoring the effectiveness of the exercises being performed to ensure children receive continuous, personalized, and measurable cognitive-training support.

3. Scope of the project

The Computerised Cognitive Retraining App provides the following functional capabilities to users:

- Interactive Tasks For Children: A wide variety of cognitive activities designed specifically for children, including Memory Games, Attention Drills, Sequential Tasks and Reasoning Games.
- Dynamic Difficulty Adjustment: The application automatically adjusts the challenge for users as their skills improve.
- Performance Tracking And Reporting: All user performance metrics are recorded and analyzed over time using various charts/graphs.
- Therapist/Teacher/Parental Dashboard: The therapist/teacher/parent has access to view user progress, assign tasks, and monitor user development.
- User Accounts And Secure Access: Users (children) will have a secure account/user ID to access their information and their supervising therapist/teacher/parent will also have a secure account/user ID for reporting purposes.
- Gamification Elements: Users can earn rewards, levels, badges and other motivational tools.
- Cross Device Compatibility: Available on all platforms; Desktop computers, Tablet computers, and Mobile devices.

This functional scope provides a well-rounded combination of accessibility, personalisation, engagement, and monitoring for individuals of all abilities/needs.

1.4 Objectives

The primary goals of the project include:

1.To create an interactive digital platform that provides cognitive retraining activities for children with disabilities.

2.To implement adaptive learning mechanisms to adjust the difficulty of tasks according to performance.

3.To build an intuitive, inclusive user interface using modern web technologies (Next.js, Tailwind CSS).

4.To increase engagement and participation using gamification techniques.

5.To create secure monitoring dashboards for parents, educators, and therapists.

6.To enable continuous improvement of cognition and measurable growth of development.

1.5 Significance of the project

The social, educational, and developmental significance of the project:

- Greater Access: Cognitive support is available to children at both home and school.
- Decreased Burden of Therapy: Therapists will be able to focus on specific intervention(s), rather than spending time on repetitive exercises.
- Increased Inclusivity: Children across a spectrum of disabilities have equal access to developmental resources.
- Enhanced Learning Outcomes: Cognitive ability is integral to both academic performance and life skills.
- Increased Motivation & Consistency: The gamified design promotes motivation and consistent use.

Better Supports for Families/Educators: Structured feedback enables greater understanding of child's requirements.

1.6 Alignment with Sustainable Development Goals(SDG's)

The project's objectives complement a number of the United Nations Sustainable Development Goals:

- Goal 1: Good Health & Well-Being - The project supports cognitive health and emotional development.
- Goal 2: Quality Education - The project provides children's learning support, including children with disabilities.
- Goal 3: Reduce Inequalitites - The project provides cognitive development for all children, regardless of abilities.
- Goal 4 Industry, Innovation & Infrastructure - The project fosters tech innovation in therapeuticeducation.

Fig1.1 Sustainable development goals

4. Prior Existing Technologies

The design, development, evaluation, and implications of EduNLP - A Rule-Based Multilingual Smart Education System to Enhance Rural Learning have been described in the following report. The present report follows a logical flow with the reader starting with the background of the problem and motivation, followed by the technical design and implementation specifics, testing and, ultimately, social and ethical requirements that define the implementation of the project. Although the chapters are independent, they also make logical sense as they connect to other related chapters such that the report can be read at the end to end or by sections when the need arises.

Chapter 1, Introduction elaborates the problem statement, provides encouraging statistics, describes the past technologies that have been used to solve similar problems, outlines the objectives of the project, and discusses how the SDGs align with the objectives of the project, in particular, SDG 4. Sometimes it goes on with the summary that directs back and forward the readers.

Chapter 2 is the literature review of the previous research in the fields of rural education, multilingual NLP, offline/low-bandwidth learning, AI in education, and policy frameworks such as NEP 2020. Weaknesses and lessons learned are brought out, and this has guided the EduNLP approach.

Chapter 3 explains the methodology applied and V-Model software engineering process in detail and aligns the project requirements with that model, module design, and testing strategy. This chapter provides specific unit, integration, and validation practices followed in the project to guarantee reliability and traceability.

Chapter 4 introduces the artifacts of planning and governance: project timeline and milestones, project risk analysis using PESTEL, and a risk matrix per phase. These sections are the records of controlling schedule, scope, and quality in development.

Chapter 5 Analysis and Design: All the requirements of the system are discussed in chapter 5 Analysis and Design, the requirements are both functional and non-functional, architectural diagrams, block diagram, flow charts, domain and operational models, communication patterns and standard that are observed in the system. It details the three-tier architecture coupled with the rule-based NLP design as addressing the project objectives.

Chapter 6, Hardware, Software and Simulation give details of hardware and software environment, development tools, code structure, and simulation/test setups employed so as to simulate the conditions of low-bandwidth and low-end devices. There are also deployment guidance and resource sizing guidance of demo and production environment.

Chapter 7 outlines testing plans, functional test cases (TP1–TP5), results of performance, accuracy measures, and conclusions made after evaluation runs. It provides the findings chapter-by-chapter, commenting on the limitations identified and optimization opportunities.

Chapter 8 (Social, Legal, Ethical, Sustainability, and Safety Aspects) gives some understanding of the broader implications of implementing EduNLP in rural settings: a social impact, legal considerations, including DPDPA/GDPR issues, ethical considerations, sustainability measures, and safety/operational controls within the systems to protect users and information.

In chapter 9, the project accomplishments are summarized, the realization of the goals is reflected on, and future suggestions such as speech interfaces, adaptive personalization, as well as increased vernacular coverage, are given to inform the further work.

Chapter 2

Literature review

Summary of Literatures reviewed

[1] Klingberg, T. (2010) – "Training and Plasticity of Working Memory"

In Klingberg's (2010) article titled "Training and Plasticity of Working Memory," he states that cognitive abilities such as working memory can be enhanced through a systematic use of training exercises. Furthermore, he shows that there are quantifiable improvements (both neurologically and behaviourally) in youngsters diagnosed with attention deficit disorders as a result of this type of training; nonetheless, he did the majority of his research in clinic settings without using any type of computer-based applications, indicating that an interactive application designed specifically for retraining at home would fill a void. **[2] Holmes, J., & Gathercole, S. (2014) – "Cognitive Training for Children with Learning Difficulties"** Holmes, J. and Gathercole, S. (2014) focused on studying memory and attention interventions for children with learning disabilities, specifically those with dyslexia and developmental delays. The findings show that while improving memorability through digital cognitive training is beneficial, as children become accustomed to the same task, their motivation decreases. Therefore, it is important that all cognitive training systems for these types of kids will include gamification or provide adaptive levels of challenge. **[3] Grynszpan, O., et al. (2014) – "Computer-Based Interventions for Children with Autism Spectrum Disorder"** This study examines the effectiveness of Digital Learning Tools on Children with Autism Spectrum Disorder (ASD) and indicates an increase in Children with ASD's level of interest/ engagement as a result of the increased visual and interactive nature of the Digital Learning Tools; however, it also finds that many Digital Learning Tools do not have monitoring tools/ dashboard for Caregivers. The App associated with this study addresses this limitation through a Progress Reporting feature.

[4] Shah, T. & Prieto, L. (2017) – "Assistive Technology for Special Education Support"

The authors describe the many types of technology that serve as cognitive aids to assist students who have disabilities. While they have demonstrated that many technologies can be very helpful, it is also clear that the majority of these products are expensive or designed for

institutional purposes. As a result, there is a growing need for affordable and scalable training options for students to use at home.

[5] Green, C.S., & Bavelier, D. (2015) – "Gamification and Cognitive Skill Development"

In their research on gamification, Green and Bavelier (2015) found that using game-like activities increases both motivation and perseverance because they provide an alternative way of practicing skills repeatedly without boredom. They also emphasize the importance of using gaming to reach therapeutic goals rather than simply for fun. This finding further supports the value of developing a structured way of completing cognitive tasks within the proposed program.

[6] Peterson, R. (2018) – "Adaptive Learning Systems for Neurodevelopmental Disorders"

This paper by Peterson, R. explains how adaptive algorithms help all learners (including those with neurodevelopmental disorders). Children who have difficulty in some areas of cognition and are strong in others will have a better chance of succeeding if they can access tools that adapt based upon their performance level. However, many of the systems currently available need to be built upon using very sophisticated Artificial Intelligence (AI). Peterson presents a system that utilizes a simple, rule-based adaptive model to allow for easier implementation.

[7] UNESCO Inclusive Education Report (2020)

The 2020 UNESCO Inclusive Education Report identifies the need for accessible digital learning platforms for children with cognitive impairments. It highlights issues related to the lack of access to, and the limited availability of, child-centered applications and therefore supports the significance of this project.

[8] Chiang, H. & Liu, C. (2019) – "Mobile-Based Cognitive Rehabilitation Tools"

In last-year's publication, by Chiang, H. & Liu, C. (2019), also, titled: "Mobile-Based Cognitive Rehabilitation Tools," it was determined that portability enhances the ability to maintain contact between the client and professional, but that existing mobile-based tools for cognitive rehabilitation do not have any ability to report back to a therapist, which is one of the main components of the project outlined in this study.

[9] American Academy of Pediatrics (2021) – "Teletherapy Adoption in Childhood Development"

The report affirms how remote developmental support (teletherapy) is becoming increasingly accepted and provides information on the future of these services. Emphasis is placed on

ensuring children's safety during teletherapy sessions, parents receiving information about their child's development, and structured reporting requirements as part of the implementation of a new system.

[10] Sánchez, J. & Flores, H. (2022) – "Digital Interfaces for Children with Disabilities"

The authors examined various user experience and user interface (UI/UX) design considerations for accessibility when designing technology for children with special needs, Including simplified navigation, use of visual cues, and lessening cognitive overload. The authors also found that many applications do not adequately meet inclusive design requirements; therefore, the proposed children's app must be inclusive in its design. **[11] Novak, I., & Morgan, C. (2022) – "Effectiveness of Early Cognitive Intervention Technologies"** This study backs up the findings from studies that state that providing cognitive assistance as a young child will result in an increase in the child's academic performance as they grow older. However, it also highlights the very real limitations of traditional cognitive therapy access, therefore making a stronger argument for the advancement of scalable digital cognitive assistance technologies.

[12] Menon, V., et al. (2023) – "Progress Tracking in Cognitive Rehabilitation Systems"

The researchers have demonstrated that there is a need to provide caregiver/educator access to data-driven monitoring of patients' progress towards rehabilitation goals through the implementation of a method that converts patient cognitive performance into meaningful and usable information (also known as "data"). This type of conversion is one of the most significant contributions of the current proposal.

Chapter 3

Methodology

Tocreate the Computerized Cognitive Retraining App for Children with Disabilities, a structured and iterative process was used to collect all necessary information for requirements, develop a comprehensive design plan, implement the program properly, and test its effectiveness. In addition, the development methodology was selected based on our understanding that all digital cognitive training tools must be able to evolve as the user's behaviour changes and their support requirements increase; therefore, an Agile Software Development Methodology was chosen.

Using the Agile Methodology enabled us to develop the app in an incremental manner, obtaining continual feedback from educators and parents after observing sample users' experiences during each incremental sprint. Each sprint contained functional modules, including cognitive exercise modules and gamified learning features, as well as dashboards that tracked the user's progress over time and provided access to adaptive materials. The incremental nature of Agile Methodology allowed for the ongoing maintenance of the highest standard of quality throughout the app's development, while ensuring that our final product remained child-friendly, engaging, and therapeutically appropriate.

1. Development Approach

Through the use of Agile Scrum as the core framework for managing a complex interactive system, we were able to create a unique system for children with diverse cognitive skills within the specifications laid out by the Agile Scrum methodology. We based our methodology on four foundational principles: Iterative Development - We would complete our work via short sprints that produced refined cognitive training components after each sprint. Incremental Delivery - Each sprint delivered usable features for the app, which included activity modules, reward systems and monitoring tools. Continuous Feedback - Review of the output from each sprint was conducted by the therapists, caregivers and the academic supervisors. Collaboration - Throughout the development process, we maintained communication, a shared understanding, and trust with all parties involved.

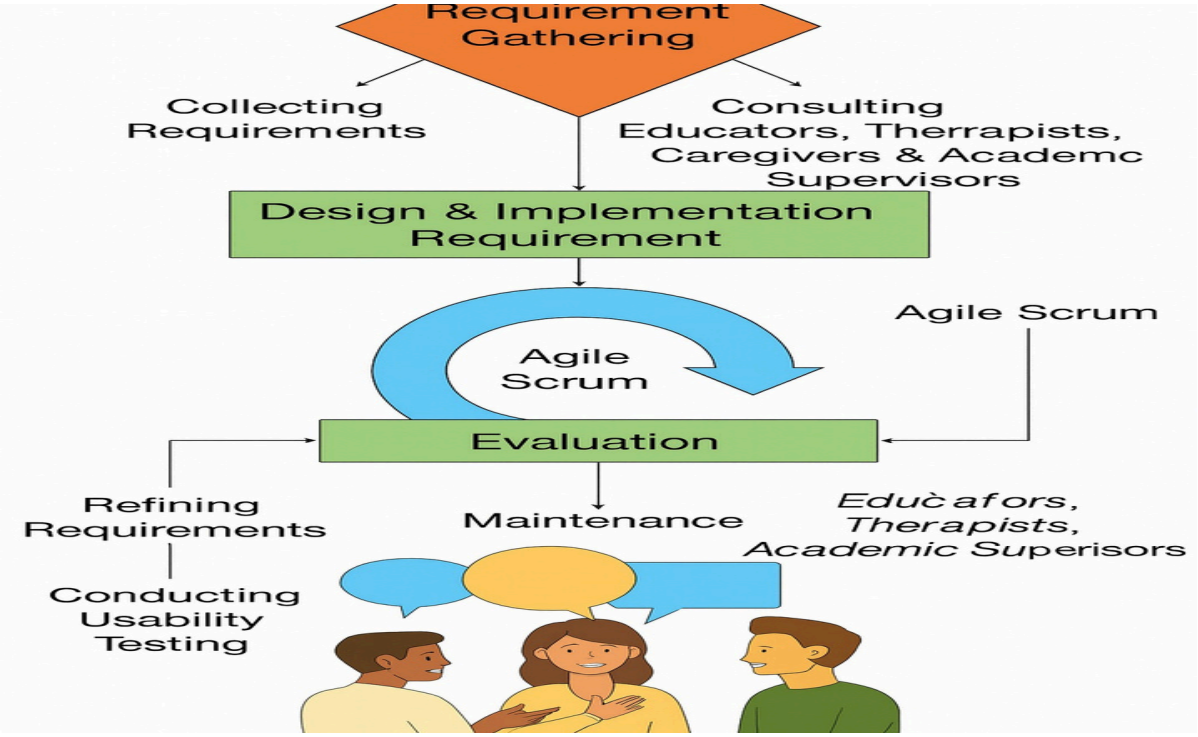

Fig. 3.1 Agile scrum methodology lifecycle flow chart

3.2 Project Phases: Our Development Journey

The hybrid phased method was adopted for all stages of this project. The structure of a standard Waterfall SDLC was coupled with the adaptability of using Agile sprints in executing aspects of the project. This combination allowed for the clarity of a defined scope and timeline while retaining flexibility to adapt to changing requirements.

3.2.1 Defining the Core (Requirement Analysis)

For this initial phase, the primary stakeholders (children with disabilities, parents, special educators, and therapists) were interviewed to learn about their needs. This was followed by a series of brainstorming sessions to identify the most important functional requirements for this new system.

The functional requirements will include:

- Encourage cognitive activity through exercises focused on memory, attention, reasoning, and visual processing
- Create a fun environment to support continued use of the system
- Provide detailed progression information in a visual format.
- Create separate dashboards for caregivers and therapists to better monitor progress.

The non-functional priorities will include:

- Easily accessible and navigable.
- Sufficient scalability for many more exercises and user groups.
- Data privacy/security established through multiple methods.
- Cross platform compatibility among devices that run on differing operating systems.

3.2.2 Drawing the Blueprint (System Design)

Following the completion of identifying Study Sites, a structural blueprint was established with the use of block diagrams, data flow diagrams as well as interaction diagrams demonstrating how the system operates. To develop reliable storage for performance records, activity logs and scores, the Database structure was developed using ER diagrams.

Cognitive Mapping was also completed to show the connection between activities and learning objectives with appropriate levels of complexity in accordance with skill development.

3.3.3 Building the Experience (Implementation)

The Development Phase involved coding the application as a set of functional elements:

The Chosen Technology Stack:

(1) Front-End Framework: React Native / Flutter for mobile access by children

(2) UI Design: Easy to Use Design, following Accessibility Guidelines

(3) Programming Language: TypeScript / JavaScript for Easing Maintenance

(4) Database: Firebase / MongoDB to provide for flexible, scalable Data Management.

The development occurred in phases:

Phase 1 – Develop & Implement Core Cognitive Exercise Modules

Phase 2 – Game-ify and Reward

Phase 3 - User Authentication and Profiles

Phase 4: Progress Dashboard

Phase 5: Enhancement of Accessibility Features e.g., large icons, audio cues, simplified steps

3.2.4 Guaranteeing Quality (Testing)

Since the app is designed for children, with different cognitive abilities it was very important to have a solid Quality Assurance (QA) process in place, multiple layers of testing were used:

• Unit Testing - tested the logic and scoring of each activity

• Integration Testing - ensured all modules worked together

• Accessibility Testing - tested for ease of reading, interacting and visual clarity.

• User Acceptance Testing (UAT) - tested by parents and teachers for usability

We also used real-world cognitive scenarios and simulated user behaviours to test activity suitability and the length of time users would engage with each activity.

3.2.5 Going Live (Deployment)

After completing testing, the system was deployed onto a Cloud-based hosting service.

The mobile application was ready to be deployed on the Android platform.

Secure links established between back-end services and Data Encryption handled by encrypted Communications with Data Encryption.

Stability, responsiveness and uptime were all maintained due to Post-Launch Monitoring of the application.

Evaluation of user interaction patterns occurred continuously and was focused on evaluating performance against what was observed from real user input.

3.3 Process Flow Diagram

The following is a description on how the system or app functions:

1. The user or child will open the app and choose a cognitive exercise.

2. The app will create tasks based on the child's ability or level of knowledge.

3. The child does the exercise using interactive components.

4. After completing the task, the system evaluates how well the child did and assigns them a score.

5. Performance data is stored securely in a database.

6. Reports on performance are accessible by caregivers/therapists from the app's dashboard.

7. Children receive motivation through earning rewards

Fig. 3.2 Progress and workflow

3.4 Use of Tools and Technologies

- Front-End Technology: React Native / Flutter is used for easy Mobile Access & Cross-Platform Development
- Styling Technology: Simple UI Design with Accessibility Considerations
- Programming Language: TypeScript / JavaScript, which provide Better Code Maintainability
- Database: Firebase / MongoDB as Data Storage Solutions; Scalable Data Storage
- Version Control System: GitHub for Code Management
- Project Management Tools: Trello/Jira to organize sprints (development cycles).
- Testing Frameworks: Jest / Postman for test automation
- Deployment Solutions: Firebase Hosting / Play Store Publishing

Chapter 4

Project Management

A structured and phased Project Management strategy facilitated the design of the Computerised Cognitive Retraining Application for the At-Home Training of Children with Disabilities. By using a structured and phased approach, we helped to maintain the ongoing flow of our project as well as keep our resources allocated efficiently towards the timelines of development.

The project lasted a total of 16 weeks, broken into several stages, which include Research, Requirement Analysis, System Design, Creation of the application, incorporation of Gamification Layers, Testing, User Accessibility Testing, and finally, Deployment Of The Solution.

All stages were sequenced to provide opportunity for multiple iterations to be completed on each stage of the development so that the application design would always remain child-centric, accessible to children with disabilities and aligned with the clinical objectives as they relate to cognitive development.

1. Project timeline

The project structuring was achieved with the use of a timeline that integrated a series of review-based milestones. A Gantt chart was used for the visualization of workflow, deadlines, and completion progress across all phases of development.

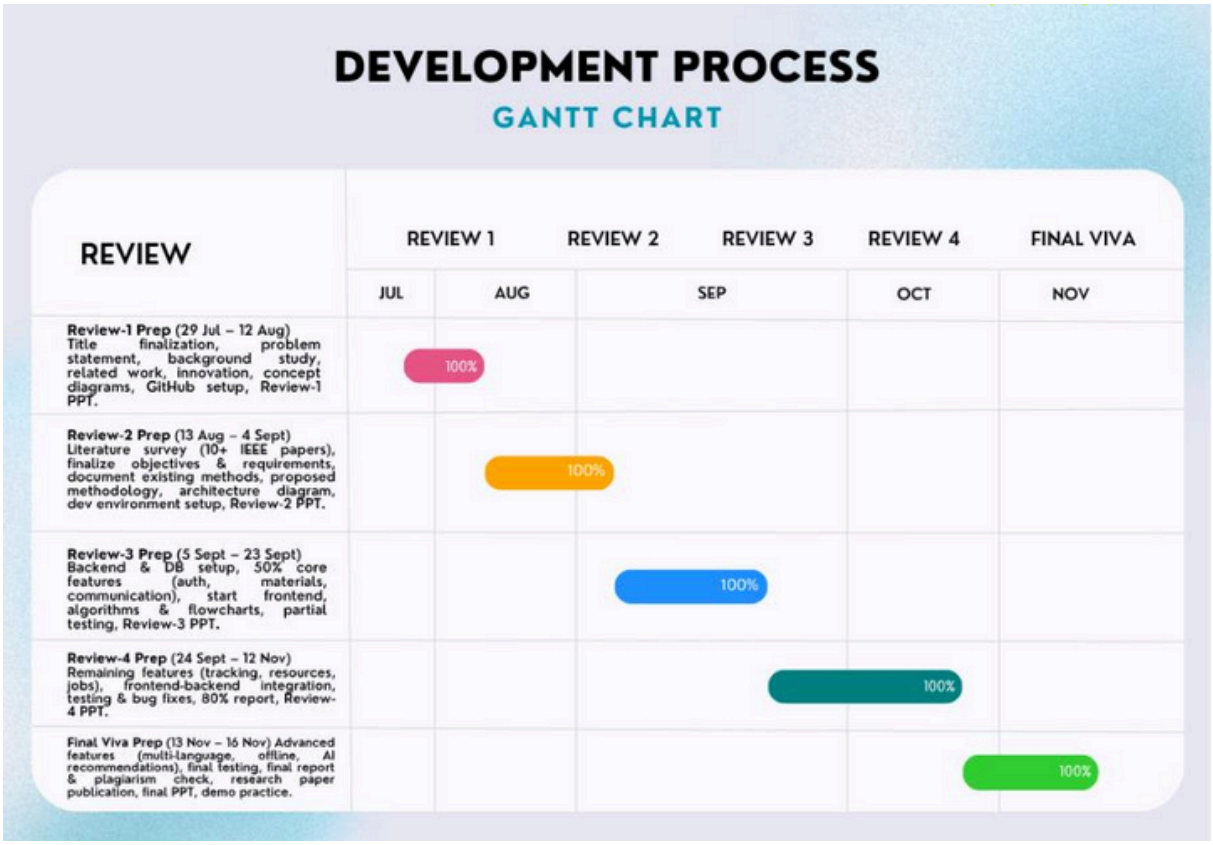

Fig 4.1 Development Process Gantt Chart

The timeline consists of five major

review phases:

- **Review 1 (29 Jul –12Aug):** Finalize title, background study, identification of innovation, problem statement definition, GitHub repository setup, and Review-1 presentation preparation.

Review 2 (13 Aug – 4 Sept): Carried out the literature survey with more than 10 IEEE papers, finalized the system requirements and objectives, proposed the methodology, and prepared the Review-2 PPT.

- **Review 3 (5 Sept – 23 Sept):** Setup the backend and database, implemented approximately 50% of the core features on authentication, content, and communication; partial frontend development; integration testing performed. **Review 4 (24 Sept – 12 Nov):** Implemented
- all the remaining modules like tracking, resource management, and recommendation logic. Conducted integration testing for the final time and compiled the report up to 80%. **Final Viva (13 Nov – 16 Nov):** Integrated advanced modules, including multilingual and offline
- support, AI recommendations; performed complete testing, plagiarism check, research paper submission, and demo practice.

The project timeline ensured that development happened sequentially, that progress was tracked regularly, and all deliverables were timely.

2. Risk analysis

The following deals with performing a PESTLE analysis to identify those factors that could pose risks to project outcomes [2]. Those key factors to be considered are: political, economic, social, technological, legal, and environmental implementation and deployment.

Fig 4.2 Example of PESTEL analysis

Table 4.1 PESTLE Analysis

Factor	Description	Potential Impact	Mitigation Strategy
Political	Government policies supporting inclusive Eduction.	Medium	Align the app with NDP.
Economic	High development and maintenance costs.	High	Offer freemium models, use open source framework.
Social	Limited awareness among parents and teachers about cognitive retraining tools.	Medium	Conduct awareness and workshops and training sessions.
Technological	Varying device compatibility and unstable internet access.	High	Provide offline and multi device compatibility.
Legal	Need to comply with child data protection and guidelines.	High	Implement encrypted data storage.
Environmental	Frequent power cuts or low device access in rural region.	Medium	Enable offline access and cloud bases backup.

Table 4.2 Project Phase Risk Matrix

Project Phase	Potential Risk	Severity	Likelihood	Mitigation Strategy
Design	Incomplete understanding of cognitive training .	High	Medium	Conduct consultations with therapist.
Development	Difficulty in creating adaptive exercises.	Medium	High	Use continuous feedback loops with experts.
Testing	Limited testing with divorce disability groups.	Medium	High	Include children with different cognitive profile.
Deployment	D compatibility issues on low-end phone	High	Medium	Optimise the app for low RAM devices.
Maintenance	Cognitive exercises outdated.	Medium	Medium	Schedule regular content update.

Chapter 5
Analysis and Design

5.1 Requirements:

5.1.1 Functional requirements (FR):

- Cognitive Activity Modules for Kids under FR1 -This system should allow an opportunity for the users and their families to interact with cognitive exercises by helping to develop and strengthen (enhance) skills including Attention, Memory, Sequencing, Visual Perception and Problem Solving in children of varying types of disabilities.
- Adaptive Difficulty Progression under FR2 -This application should allow the user's difficulty level for tasks to be adjusted based upon their performance to prevent them from being overwhelmed and/or under-stimulated.
- Caregiver Monitoring and Progress Dashboard under FR3 -This application needs to track how much time the user has done each activity, how many times they have completed the activity correctly, the accuracy of the user's actions, and the people's overall trend line of progress can be displayed to parents or therapists through an easy and clear visual analytics dashboard.
- Gamification and Motivational Reinforcement under FR4 -The application should have multiple ways to encourage and motivate users to complete exercise-related tasks and the activity of the user. A very important aspect of the gamified model is the use of badges (rewards) and e-messaging systems, different visual stimuli to encourage participation (increased engagement) on the user's part during their therapy.
- Access & Multi-Sensory Interface under FR5 -The interface needs to include simplified navigation and easy access to, as well as audio cues for users who may be cognitively or physically limited, as well as a range of colour contrast-safe colours and use of larger buttons, and a possibility of auditory narration to help children with different cognitive or motor limitations.
- Home-Based User accounts & Continuation of Sessions under FR6- Users should be able to continue with their cognitive activity from home, record their activity history of cognitive performance, and securely store their individualised profile information.

5.1.2 Non-functional requirements (NFR):

- NFR1 - Accessibility Compliance: The application should comply with the WCAG 2.1-AA standards to ensure that children who have cognitive, motor, and sensory disabilities can use the system.
- NFR2 - Performance and Responsiveness: Screens of activity will load in no more than 400 ms. Activity transitions must occur smoothly. Otherwise, users may find it frustrating or disengaged.
- NFR3 - Safety and Data Privacy: User information is kept safe using encryption. Sensitive information regarding children must adhere to ethical practices and privacy regulations. Identifiable behavioural profiling will not be allowed.
- NFR4 - Reliability and Stability of the Session: Application will operate consistently and without any crashes during user activities and allow for users to continually conduct training.
- NFR5 - Scalability and Modular Expansion: The architecture should be able to accommodate the future addition of cognitive modules, languages, and therapeutic areas without re-engineering the system.
- NFR6 - Offline Capability (optional mode): Core exercises should be operable in non-internet connected households for children living in low-connectivity environments.

2. Block Diagram

The fundamental architectural elements of the Computerized Cogni9ve Retraining App consist of:

Cogni9ve Ac9vity Engine (the logic used for memory, aBen9on, sequencing tasks)

Adap9ve Difficulty Module (performance assessments and adjustments to the level of difficulty)

Gamifica9on Layer (rewards, badges and visually s9mula9ng components)

Caregiver Dashboard (progress analy9cs/reports and insights)

User Profile & Progress Database (secure cloud/local storage).

The arrows demonstrate where data flows for:

✅ interac9on from the child to the Ac9vity Engine

✅ performance output to the Adap9ve Difficulty Module

✅ storage metrics to Caregivers Dashboard

the UI Layer and accessibility capabili9es

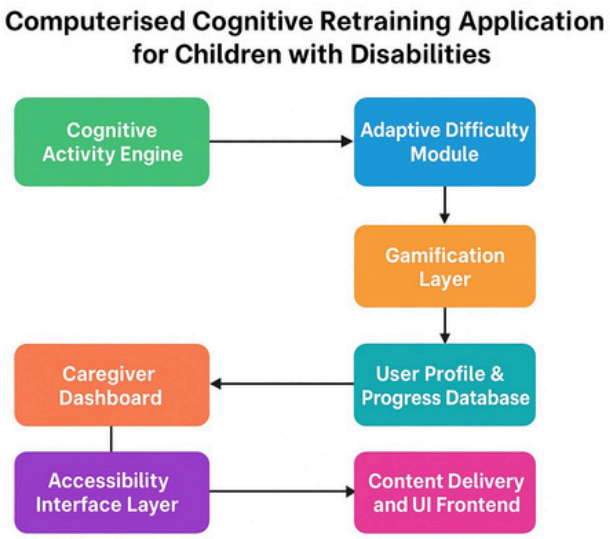

Fig 5.1 block Diagram of Cognitive retraining app for the children with disabilities

3. System Flow Chart

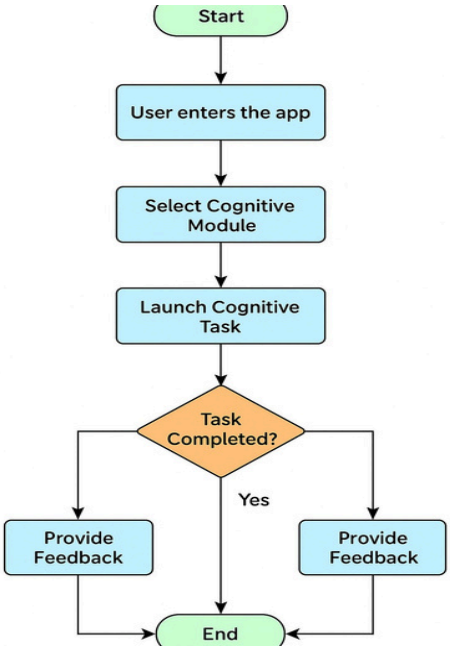

Fig 5.2 System Flow Chart of EduNLP

The process for this system starts when the child accesses the application and chooses how they prefer to interact through the accessibility features (it can also automatically load their profile preferences). The process will continue as follows:

- Dashboard home page appears with easy navigation features;
- User selects the type of activity (attention, memory, visual tracking, etc.);
- The child must complete the activity instructions via written instructions and audio instructions;
- The child will complete the task;
- The system will evaluate the child's performance using the following measures: accuracy, time taken to respond, focus level;

4.Designing units

Modules and responsibilities:

4.1 Presentation Layer (Frontend)

In the presentation layer of the application, you will find the primary component that allows everyone; children, parents, therapists, etc., to interact with the application is designed by using a React or Flutter frontend or whatever UI framework you use.

In this layer, we will create a UI for children that is colour-coded with big buttons and bright visual iconography and audio cues, along with selection screens for exercises that are designed to correspond to the assigned cognitive domains of children (memory, Attention, Sequencing, visual perception, and so forth). In addition, we will create dashboards that allow parents and therapists to monitor their children's progress through Exercise.

Lastly, we will provide support for children with varying levels of cognitive Ability by including the following features in the presentation layer:

- Text to Speech
- High Contrast Mode
- Simplified Navigation
- Multilingual Instructions

Based on the features listed above, we can ensure that children of all cognitive abilities will have the opportunity to easily use the application.

4.2 Cognitive Training Engine

This module manages the production, dissemination, and modification of therapeutic activity.

Core function includes:

✅ Determining which exercise(s) are suitable for an individual's disability type and level of functioning

✅ Structuring task instructions

✅ Dynamically adjusting the level of difficulty of an exercise or exercise series based upon performance

✅ Giving reinforcement feedback (visual audio, badges, praise cues)

This module serves as the "brain" of the complete system. It assures that training sessions are targeted toward verifiable developmental goals.

4.3 Review & Assessment Component

This component continually assesses users' performance by assessing their: ☑️ response time ☑️ number of errors making/losing ☑️ times/tries on task ☑️ how many times completed. It produces standard Evaluation Logs for use by parents and clinicians to evaluate the success of intervention. Milestones can be tracked, summaries can be created on a weekly basis and Scores can be evaluated by area or domain with the use of the alert system to notify users of any regressions or difficulties related to an individual's progress.

4.4 Parent & Therapist Management System

The Parent & Therapist Management System allows authorized adults to manage and monitor the child's training lifecycle:

✅✅✅✅✅ set exercise plans

✅ schedule training sessions

✅ view cognitive development charts

✅ add personalized difficulty adjustments

✅ provide guidance

Therapists can remotely adjust therapy paths based on progress analytics.

4.5 Motivational and Reward Systems

For children with attention and cognitive difficulties, motivation is vital. Gamification components include:

❑ Stars, Badges, Levels, Animations

❑Positive Reinforcement Notifications

❑ Optional Recorded Praise from Parent(s)

Enhances consistency, motivation, and involvement in therapy sessions.

4.6 Data Storage & Security Layer

The Data Storage and Security Layer (DSSL) provides for the safe handling of sensitive data about children.

The primary functions of this layer include:

▪ Safely saving therapist notes, training records, and session logs.

▪ Providing secure encrypted methods for users to authenticate themselves.

▪ Complying with the privacy rights of minor children.

▪ Providing the ability to back up and recover all data.

▪ Optionally providing de-identified reports on collected research data.

Cloud-based databases can be used to provide remote access to your data.

4.7 Administrative Dashboard

The Administrative Dashboard is designed for school supervisors, clinics, and coordinators to provide.

Some of the information provided in this section includes:

Metrics (usage statistics),

Heat Maps (improvement),

Performance Insights by Disability Category,

Reports (export to PDF or Excel), Monitoring App Usage on Multiple Children.

The Administrative Dashboard provides information to support decision making regarding how much therapy to scale up in the future and for use in institutional reporting.

Table 5.3 System Architecture Layers

Layer	Components	Description
Presentation Layer	HTML5, JavaScript (ES6), Tailwind CSS	Provides responsive UI for content access and chatbot interaction.
Application Layer	Node.js, Express.js	Manages APIs, rule-based NLP logic, and mentorship template retrieval. Stores
Data Layer	JSON repositories	multilingual templates, user profiles, and progress data.

This structure enables effective communication via RESTful APIs, as well as language-based scalability.

5.Standards

• Communication between the Frontend application and API

The Front-End application (Mobile/Tablet/Desktop) communicates with the Back-End Services via a secure encrypted channel over HTTPS/TLS - RFC 5246/8446.

API's are based on REST and JSON conventions, which provide a lightweight way to transfer data over an unreliable internet connection that is most suitable for low-attention users, as well as in a household Internet environment.

Only authorized domains with authenticated therapists and parents can access Child Data by enforcing CORS policies

• Privacy and Safety of Children's Data Given that the platform's user base consists of children and since progress is associated with disabilities, the platform has adopted:

- Principles of Child Data Protection Act (COPPA) governing how data on children is collected, used, stored, etc.
- Explicit Information and Parental Consent

- Minimal Information Collection

- The Right to Erase Personal Data

The platform ensures compliance with the Digital Personal Data Protection Act in India and adheres to its applicable principles.

• **Cognitive Assessment and Therapy Standards** The Cognitive Assessment and Therapeutic Practice Standards (CAPS) specify how digital training should parallel evidence-based rehabilitation practices and the ICF (International Classification of Functionality), Disability and Health), Evidence-Based Structured Therapeutic Activities in the Following Standardized Cognitive skill domains:

>Working Memory

>Auditory Attention

>Visual-Spatial Reasoning

>Sequencing

>Problem Solving

The alignment of digital exercise design and other progress metrics with these standards provides assurance that digital training adheres to established rehabilitation methods.

• **Accessibility Standards** The User Interface conforms to the Web Content Accessibility Guidelines (WCAG) Version 2.1, Level AA. The compliance includes the following:

➤ High contrast eye-friendly colours.

➤ Built-in text-to-speech functionality.

➤ Voice-activated navigation interface.

➤ Touch-friendly interface with large tap targets.

➤ Icon/text label pairs.

This was designed specifically for use by children affected by cognitive, motor, speech, and perceptual disabilities.

• **Language & Localization**

Utilizing Unicode UTF-8 for displaying different language options. Formatting date/time and audio prompts for the user's localized region (time zone). Optional use of narration in the user's native regional language for users who may need help understanding the instructions or prompts.

• **Motivation Standardisation and Gamification**

Rewarding mechanisms should comply with the child-safe psychological reinforcement principles of:

✅ Pacing of rewards should not lead to addictive behaviour

✅ Introducing positive reinforcement in place of punitive measures

✅ Calming audio and visual styles to promote healthy motivation

This allows for motivating factors without over-stimulating children, particularly those with ASD and/or ADHD.

• **Device & Platform Compatibility** The application is compatible with consumer-level devices that are readily available in homes and schools:

✅✅✅✅

✅ Android Tablet

✅ iPad

✅ PC with Touch Screen

✅ Affordable Access Keyboards

For Communication with wearable or IoT-based devices, the app communicates via Bluetooth LE or Wi-Fi 802.11ac/n.

• **Data Storage & Encryption**

All stored data, including cognitive performance logs, is protected by:

✅ Encryption at rest (AES-256).

✅✅ Encryption in transit (TLS 1.2+).

✅ Role-based access control.

Only therapists and authorized guardians can view the cognitive records.

• **Reference Architecture Alignment** The WHO Digital Health Intervention Framework is referenced within the solution; this means that the system supports several areas of remote therapeutic guidance, rehabilitation outcome monitoring, and digital ecosystems for caregiver support.

The solution is also poised for the future integration of assistive programs for clinical purposes.

6.Mapping with IoTWF reference model layers

Even though the Computerized Cognitive Rehabilitator Application functions primarily as a digital therapeutic (or platform); however, many components of the Computerised Cognitive Rehabilitator Application Ecosystem (e.g., assistive devices, monitoring and tracking of usage and progress, caregiver interactions and therapist oversight) may also be aligned in meaningful ways across each of the layers presented on the IoTWF's layered structure. Mapping the various components of the Computerized Cognitive Rehabilitator Application and Ecosystem to the IoTWF model gives a clear understanding of the components of the system, how the various components interact with each other, and how the various components will function together.

Physical Devices and Controllers (Layer One) – This portion of the architecture refers to the devices that will be used by children, their family members, and their therapists in order to access the app. Most likely, they will be using these devices to learn and complete activities for learning. Examples of devices used by users of this app include:

- Tablets that a child uses to complete their exercise activities.
- Touch screen devices used in schools or in therapy centers.
- Adaptive assistive devices (examples: switch inputs, speech buttons, etc).
- Optional wearables (attention tracking accessories).

- The physical devices in this layer provide the child with the primary form of interaction with the tasks of cognitive engagement as well as for input to the app and feedback from the app.

Connectivity (Layer Two) – We connect to the application or app to interact with Cloud services. Based on where the user accesses the app from, connectivity is achieved through the following methods:

If the user is connecting from home, then they will have access to Wi-Fi or mobile data.

If the user is connecting from a therapy center, then they will connect using secured institutional networks (via VPN).

If the user has an IoT assistive device, they will connect via Bluetooth LE.

Secure Transport Protocols (ie. HTTPS and MQTT (for lightweight telemetry)) allows for a secure and efficient transfer of data.

The Edge computing functions (Layer Three)

User's cognitive load can be eased and their latency reduced by having some functions take place on their device, for example:

✅ The ability to access a few exercises without being connected to the internet

✅ Tracking progress with local caching of session information prior to synchronising back to the internet

✅ Therapeutics mini-tasks being scored in real-time

✅ A voice/audio cue being delivered

In addition to this, Edge Processing allows for a seamless user experience for children who may be easily distracted by short attention spans or inconsistent connectivity.

Collecting Data(Layer four) The information collected from the user's activity, including performance metrics, interactions with the program and logs from their sessions, is stored in backend databases. Examples include:

✅✅✅✅

✅ Information about the number of tasks completed

✅ Patterns of accuracy and response times

✅ Adaptive difficulty information from calibration sessions

✅ Notes made by the caregiver and/or Therapist.

This results in a collection of data that can create a structured pathway for a user's personalised rehabilitation over a period of time.

Data Abstraction(Layer five)

Middleware and APIs at this layer assist in providing standardized methods to access stored data, including:

• Progress retrieval via REST-based APIs

• Therapist dashboards that display structured learning metrics

• Anonymized datasets that can be used for either research or institutional reporting purposes

• Raw interaction logs transformed into interpretable indicators.

This layer ensures that every application module receives a consistent set of clean and unified cognitive performance data.

Applications(Layer six)

Application processes are those that users directly interact with:

• Cognitive retraining activity modules • An adaptive learning engine which adjusts difficulty levels • A gamified reward system for incentive purposes • A caregiver monitoring portal • A therapist management dashboard. Therapeutic engagement and supervision take place here and are meaningful.

Collaboration & Therapeutic Processes(Layer seven) The Uppermost Layer (C7) Of Collaborative Therapeutic Processes Is Where Decision-Making And Human-Level Outcomes Occur, Including:

⏩⏩⏩⏩⏩

⏩Visualizing & Interpreting Individual Progress Indicators By The Therapist

⏩Adjusting Individualized Learning Pathways Based On Progress

⏩Including Caregivers In Providing Reinforcement Strategies

⏩Providing Institutional Reporting For Inclusive School Programs

⏩Creating Long-Term Developmental Planning/Documentation

This layer enhances the ability to achieve the goals of Rehabilitation, To Prepare Individuals For School/Academic Success, And To Follow-Up With Clinical Services.

8.Domain model specification

Users of the System The User (Child/Caregiver/Therapist) entity includes the Child and all caregivers/performance support of the Child. All Users of the system will be included in this entity.

User Details

• **User_ID**

• Name of the User

• User Role - (Child/Caregiver/Therapist)

• Age of user (only applicable for all Child users)

• Disability Category - (this is optional and is non-identifiable)

• Preferred Method of Communication (text, visuals, audio cues)

•Language Preference of User

Cognitive Exercise Module - The Cognitive Exercise Module represents each activity in Cognitive Rehabilitation that are available through the System.

Key Attributes of the Cognitive Exercise Module:

• Module_ID

• Title - of Cognitive Exercise Module

• Cognitive Domains - Memory, Attention, Visual Perception, Sequencing, Reasoning etc.

• Difficulty Levels

• Task Description and Instructions

•Media Resources - Images, Audio Prompts, Animation(s)

Session Record

This is a record of all training sessions completed by a particular child and contains key attributes like session_id, child user_id, module_id, date created, length of duration, the number of attempts made, percentage accuracy score, how long the child took to respond to the questions, how successful the child was in adapting to adaptive difficulty, and more.

Progress Profile

The Progress Profile provides a comprehensive overview of a child's performance through trend analysis and is designed to help support adaptive learning and therapist review. Key attributes of this entity include the following: progress_id, child user_id, baseline assessment data, improvement metrics, the recommended difficulty level, the reinforcement indicators for the child, and alert flags, including regression or lack of engagement with the system.

Reward & Gamification Tokens

Reward and Gamification Tokens provide the record of the points, badges, and motivation reinforcements children earn when using the program. Key attributes include reward_id, child user_id, reward_type (badge, star, level up), trigger condition, unlock history, and more.

Therapist Notes/Intervention Plan

This is where professional therapists record their observations of the child, including changes they make to their recommended exercise and follow-up schedules or paths. Key attributes include note_id, therapist user_id, child user_id, observation entry, exercise plan, and follow-up schedule. •

System Analytics Record

The System Analytics Record stores anonymised usage metrics to aid in evaluation and future development.

Attributes:

record_id

Timestamp

Metric Type (Engagement Rates, Module Popularity, Completion Consistency, and Accessibility Usage)

Aggregated Values

Relationships

✅ User (Child) to Session Record (1 to many)

A User (Child) may participate in numerous Training Sessions

✅ Cognitive Exercise Module to Session Record (1 to many)

Every Session is related to a particular Cognitive Exercise Module

✅ User (Child) to Progress Profile (1 to 1)

Each User (Child) has their individual continuously developing Progress Profile

✅ User (Child) to Reward Tokens (1 to many)

User (Child) will earn a variety of multiple Reinforcement Rewards

✅ Therapist (User) to Therapist Notes (1 to many)

The Therapist (User) can Supervise several Users (Children)

✅ User (Child) to Therapist Notes (1 to many)

A User (Child) may receive multiple evaluations documented as Therapist Notes

✅ Progress Profile to Module Recommendations (indirect association)

The Adaptive Engine will recommend a future Module based on the Progress Profile

The System Analytics Record will store all data collected from all the entities listed above. This record will be used for purpose of Monitoring only; no direct interaction with this record will be provided to users (i.e., the User could not directly access or modify the data contained within the System Analytics Record) .

9.Communication model

The Communication Model works by using several different ways to communicate between Children, Caregivers, Therapists and the Backend Processing Components as a way to provide seamless communication with stakeholders. The communication model supports "real-time" interaction while performing "cognitive" activities within the application and delegates background tasks over the asynchronous channels allowing ongoing access to and responsiveness from the users throughout their experience with the application.

• Communication via HTTP or HTTPS in Real Time with Synchronous Messaging

This allows for real time interaction as needed while an application is running. Information exchanged through this modality will be between the front-end user interface and the back-end services of the application.

✅
✅ This method provides for:

- Cognitive training module launches,

- Exercise response submissions,

- Instant performance feedback retrieval,

- Updates to adaptive difficulty settings,

- A view into the Caregiver Dashboard,

- A therapist to log in and assign a child.

Synchronous HTTP/HTTPS communications provide low latency responses that are appropriate for children with short attention spans, and those who require accessibility features.

• Background Event and Asynchronous Messaging

The progression through either the current user interface for a specific training session or through the current training session is processed outside of the usual training environment so that any user-interactions to view or report on their progress are unaffected.

✅
✅ Used For:

Creating progress reports

Tracking user engagement Stats

Providing longitudinal tracking of improvement trends

Sending notifications to Caregivers

Storing aggregated, anonymized analytics and information Using Background Jobs and Pub/Sub-based Events, these background services operate
seamlessly in real-time to ensure a smooth application process.

• AI Communication:

AI and ML use cognitive assessments as a way to use the Adaptive Reasoning Engine to leverage score performance data to learn user performance over time.

Uses:

Detecting whether a child has a learning challenge or has made progress.

Recommending the difficulty of the next module.

Identifying areas where the student has weak cognitive abilities.

Flagging responses that are atypical of the student for review by the therapist.

• Accessibility Interaction Channels

Due to its focus on supporting children with various ability levels, the program will require multiple ways for a child to communicate.
Examples may include:

- Audio directions

- Visual symbol guides

- Tap or gesture methods

- Compatibility with screen reader devices

Using these channels will allow equal access to all children to participate fully in the program.

10 IoT deployment level

10.1 On-Site Tier Description The On-Site Tier refers to devices used directly by children as part of cognitive training session, either at home, therapy centres, and/or schools. These devices include tablets, laptops, and/or assistive interaction devices specifically designed/adapted for use by children with disabilities. There are several key features of the On-Site Tier:

- Training exercises are able to run with no internet connection

- Progress records and activity responses are stored locally

-Children can continue participating in training sessions without interruption

- An offline mode is built in to help avoid learning gaps for children in areas with poor connectivity

This enables assured access to, as well as comfort during use and uninterrupted cognitive engagement for the child during the training.

10.2 Edge Tier The Edge Tier is a small intermediary processing layer that syncs and optimizes data coming from the child's device, and can be implemented as:

small (lightweight) edge service

secure local gateway device

school/therapy-centre (rural) network hub

The primary function of the Edge Tier is to Collect and store data from the child's device (session logs, performance metrics, and behavioural patterns) temporarily until the internet connection has been re-established, while providing Edge Services, such as:

identify error frequency trends (errors that occur frequently) and average response time for tasks;
identify levels of task difficulty and adapt accordingly during a session.

The Edge Tier essentially reduces latency for children who are using devices in locations with rural and/or unreliable internet connections while providing additional security and reliability for sensitive userdata.

10.3 Cloud Tier The Cloud Tierconsists of the most significant cloud-based management and computing capabilities necessary for Adaptive Cognitive Re-Training. Key capabilities offered by the Cloud Tier include:

AI Performance Analysis and Progress Modelling

Personalised Algorithm for Difficulty Adjustment of Tasks

Centralised Secure Database for User Profile

Therapist and Parent Monitoring Dashboards

Reporting, Recommendations, and Interventions Planning

Remote Updates of Exercises, Visuals, and Assistive Interaction Modules

Provides Scalability, Centralised Monitoring, and Data-Driven Insights for Therapists, Caregivers, and Educators.

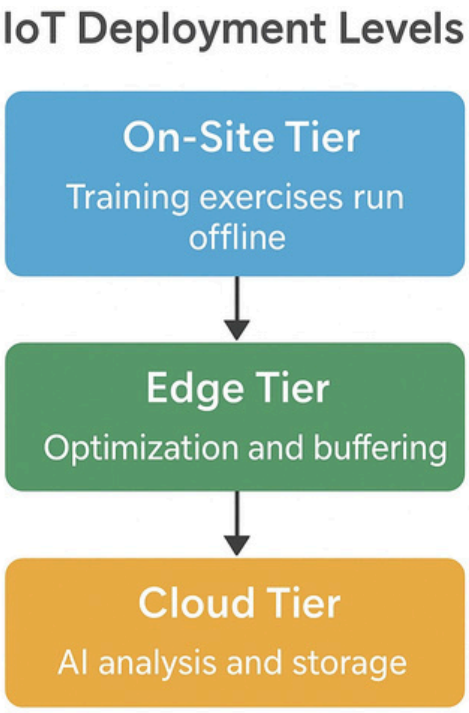

Figure 5.10:Iot deployment levels

11. Functional view

• User Interaction: The way in which children, parents, or therapists interact with the cognitive retraining app is
represented in this layer. Four aspects are essential to this layer:

* Screens designed for use by children

* Navigation that utilizes touch and gesture based inputs

* Speech-assisted prompts and visual cues

* A progress Dashboard.

Additionally, session scheduling, selecting level of difficulty, and multiple languages, help make the interface user friendly for all children regardless of what level of disability they may have.

• Cognitive Task Interpretation & Personalization Engine

The module analyzes user actions and input, including time taken to complete a task, how accurately they completed it, signs of fatigue, and whether they need help. The AI engine uses

this information to understand the cognitive intent of the user's actions. Based on this understanding, the AI engine then adjusts the difficulty, type, and duration of the task. For example, if the child appears to be struggling with a task, the AI offers clues or easier tasks. If the child is completing tasks successfully, then the AI will gradually increase the cognitive load on the child.

• Training Session Workflow

The organisation of Cognitive Training session components beginning with a "Session workflow." The cognitive training session workflow is the organised progress of cognitive exercises through several stages: warm-ups; cognitive training core tasks; tasks enables skill reinforcement; and cool down. The workflow component also keeps track of the required inputs for each stage and prevents the therapeutic stages from being missed. Each individual exercise/ task is mapped to be related to specific therapeutic areas including memory, attention, sequencing, problem-solving, and/or providing stimulation for language related deficits.

• Reward, Motivation & Reinforcement System

Instead of simply giving you money, the rewards, motivational & reinforcement systems are based on rewarding a person with:

* Reward Tokens

* Badges and Stars

* Visual Recognition

* Sound Recognition

* Encouragement from Parents/Therapists

Motivation remains high and frustration is reduced. This is especially important for children who have learning, developmental, or cognitive disabilities.

• Progress Recording & Performance Tracking

This module will produce the session logs for each client, indicate cognitive improvements, growth charts for each skill, and also milestones or accomplishments. In addition it will store:

Duration of each session

Accuracy of responses

Average time taken to respond

Completion rates (Trends over time)

Consistency levels of Attention

When assistance is provided to the client from their therapist.

This information will be used by both the therapist and the parent to objectively measure progress.

• Reporting & Therapeutic Insights

The device does quantitative data conversion into a useable format. This module provides:

Weekly or Monthly Performance summary

Performance Heat Maps

Next Steps/Cogitative suggestions

Alerts for Regression/Difficulty Spike Reports that aid in Clinical Decision-Making and Individualize Education Plans.

12 Mapping IoT deployment level with functional view

• **On-Site Tier Devices (Home and Therapy Centers)** This tier encompasses the ways that children interact with the cognitive retraining app. Each type of device includes tablets, touch-screen devices, assistive switches, or voice-interaction devices. In addition to functioning when there is no Internet access, the system can do the following:

✅✅✅

✅ Perform offline versions of each Cognitive Exercise

✅ Store session results offline until the Internet connection can be restored

✅ Allow Kids to continue with Theme Based Therapy sessions without any disruption

This supports access and consistency; both are necessary elements for Children with disabilities related to Attention, Memory or Learning.

• **Edge Tier (Assistive Hub / Local Processing Gateway)**

Edge Tier provides an interim processing layer with minimal weight. Whether placed on a caregiver, Local Hub or facility server, this layer provides support for:

✅✅✅✅ Synchronizing stored session data

✅ Performing preliminary scoring and filtering performance

✅ Monitoring device health and interaction responsiveness

✅ Maintaining data integrity during delayed transfers of data

The Edge Tier is designed to provide lower latency, support for a more fluid therapeutic process, and reliable transfer of data, especially in school, special education centres, rehabilitation units, and other similar environments where large amounts of data are transferred often and quickly to multiple sources. **• Cloud Tier (Central Cognitive Intelligence & Management System)**

Cloud Tier(Central Cognitive Intelligence and Management System) - This tier provides Centralized Computational through a clinically-based support system for Clinical Decision Support Asks and includes many of the following tasks Automated using Artificial intelligence: AI Adaptation; Therapeutic techniques determination and therapy model calculations; Predictive Models for tracking of user performance over time; creating a dashboard for both therapists and Parents; Providing reports, insight, milestones and Alerts; Manage Users and update application(s).Utilizing Cloud to help scale, remotely monitor, allow multiple users in one central location and maintain regular updates that meet the Therapeutic Guidelines.

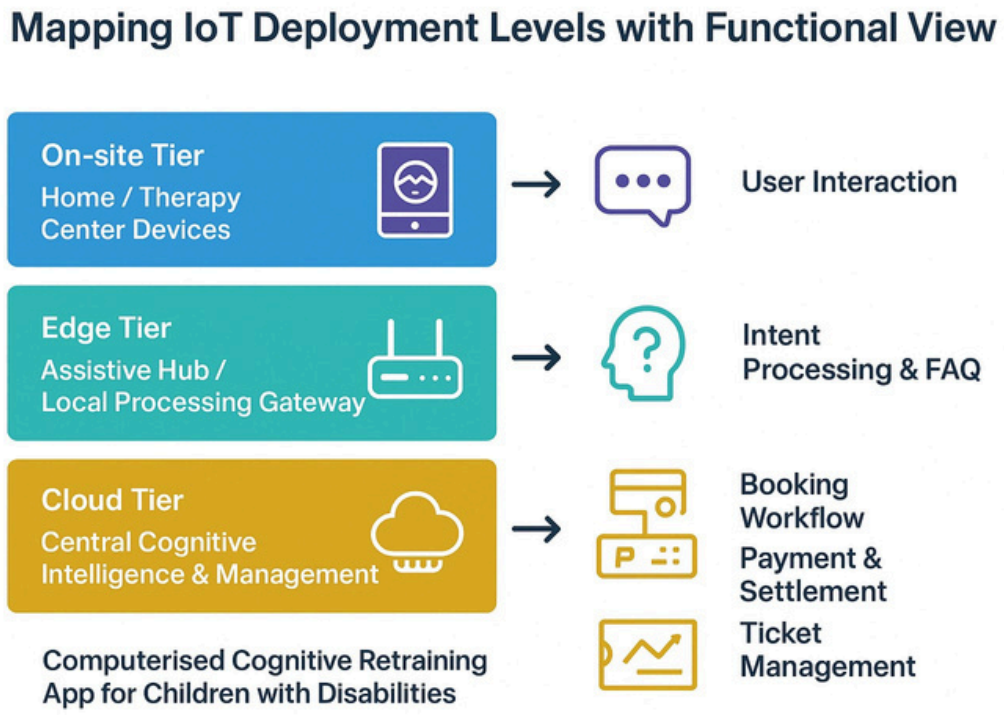

Figure 5.12: Mapping IoT deployment level with functional view

13.Operational view

• **Application Hosting & Deployments** The mobile or tablet training program and cloud-based therapist dashboard (collectively referred to as “training applications”) are delivered using CI/CD pipelines (Continuous Integration / Continuous Delivery) in order to provide uninterrupted service to therapists and their clients. Feature flags help to safely test new training modules, algorithmic difficulty, and user interface accessibility. This way, if something goes wrong or needs further tweaking, all changes can be validated or approved by either a smaller user group or just a subset of users before they are made universally available. • **Monitoring:** To ensure that the system is functioning as intended during therapeutic sessions, we will continuously monitor the performance of the system. Metrics used to monitor system performance include the completion rate of therapy sessions, latency of loading exercises, and frequency of errors that occur. When a metric exceeds its threshold, alerts will be generated to ensure that the child's therapy session is not interrupted. In addition to providing a means of monitoring the cognitive load of a child, usage analytics are used to track the engagement level of a child and the child's interaction with the system's accessibility resources for future improvements. • **Backup & Data retention:** The system stores therapy progress data, cognitive performance logs, and history of sessions based on established retention policies for each type. Automated daily backup ensures that no therapy progress can be lost through automated daily backup processes, especially for therapy progress for tracking via long-term progress tracking. A minimum of three months of backup data available so therapists and caregivers to access previous reports should they need to reference earlier information in case of failure. • **Incident response:** The operational handling of every incident can be broken down into several steps. Each step describes how to detect an anomaly based on an alert and investigate the problem through the use of dashboards and logs. Corrective actions may be implemented, for example: rolling back a faulty content update or restoring access to a patient's information. To ensure that future incidents are managed effectively and adequately, a post-event review is conducted for all incidents. These post-event reviews will assist with building a resilient system and maintaining patient safety.

• **Device & Kiosk Maintenance (if used in therapy centers)** The therapy devices used at the Therapy Station provide an ongoing heartbeat signal to notify the user that the device is still functioning correctly. The "off-line" capability of the device allows for the continued use in a remote location, while also being able to sync when returned to an on-line location. Each week there are log files and training data that are archived every day for the protection of user and storage of funds and the smooth operation of the application by children with differing motor and cognitive capabilities.

• **Security & Compliance Operations** Child data protection and compliance with educational and healthcare privacy standards are the primary consideration in protecting children's data through the implementation of Security controls. Security controls include periodic rotation of API keys, quarterly reviews of access permissions for Caregiver-therapist, regular updating of dependent libraries (patching), and annual Security audits. Additional safety measures help ensure that sensitive Progress Data remains secure both while being stored (at rest) and being transmitted (in transit).

14.Other Design

• Cognitive Artificial Intelligence/Assessment Models can be swapped out. The adaptive training engine and cognitive analytic feature are not integrated within the main application process. This allows the ability to replace or upgrade all AI scoring models, accessibility classifications, or difficult adjustment systems later on without significant requirement changes to the application. This allows for the adaptability to new research standards or therapeutic methodologies as they become available as well as future advancement of the cognitive analytic component.

• Pluggable Training Content & Therapy Modules

All of the various exercise components, including games and sensory activities, are provided via a unique set of modular adapters. As new therapy modules, localization packs and other types of therapeutic content from various professionals become available, they may be integrated easily into the existing system through these adapters.

• The Application Provides an Offline Mode for Rehabilitation at Home or Remotely.

The app can operate without Internet access for children who may experience sporadic or weak Internet connection while going through rehabilitation. Training sessions, progress logs, reward points, and scheduling preferences will be saved locally to the device until the user is reconnected to the Internet. At that point, all data will be securely uploaded to and back-end systems updated via the use of secure cloud storage, allowing therapists and caregivers complete access to the child's developmental progress.

• Child Safety through Privacy-by-Design For tracking cognitive rehabilitation, the system stores only what is necessary. The system only
saves personal information that could identify you; additional private information is saved securely when not transferred and while being sent over the internet. Consent flow documents provide that the guardian must give explicit permission for the use of their data. There is no disclosure of any information to researchers, analytics or anyone else outside the system without express permission from the guardian.

• Session Integrity, Rate-Limiting & Safe Retry

Modifications to ensure that training completions are processed only once include the use of a session identifier and an action token so that duplicate entries or inflation of progress is avoided. Safe data synchronization is achieved using server-side retry processes to accurately maintain cognitive score, reward allocation, and the ability to progress through milestones even when the network connection is less than stable.

Chapter 6
Hardware, Software and Simulation

1. Hardware

The Computerised Cognitive Retraining System is a software-based therapy system designed to run on laptops, phones, and aids in a number of environments including at home, in a therapy center, or in a special education environment. In addition to being a digital program, there are many optional yet beneficial pieces of hardware that can be utilized in conjunction with the system that will give children with a wide variety of disabilities increased access to more engagement and more measurable improvement.

The types of hardware supporting this are separated by an ecological system that includes hardware for user interaction, hardware for software processing, and hardware for assisting with accessibility to products and services.

2. Software Development Tools

1. Code Editors / IDEs – are software programs that enable you to write, debug, and organize your code.

Why it Matters: All of these code editors/IDEs have features such as syntax highlighting, extensions for adding functionality, debugging capabilities, and support for autocompletion while you're typing.

2. Version Control Tools – enable you to keep track of changes you've made to your code, and to collaborate with other developers.

Why it Matters: These tools enable you to revert to earlier versions of your code, to create branch versions of your project, to collaborate with other developers in a team environment, and to automate the build and deployment process using CI/CD (Continuous Integration / Continuous Deployment).

3. Build & Automation Tools – automate compiling, creating a packaged version of your project, and deploy it.

Examples of Build & Automation Tools:

Why it Matters: Build & Automation Tools allow you to reduce the amount of manual work you have to do when building a project, and, at the same time, provide consistency when building your projects.

4. Continuous Integration / DevOps Tools – used to test, integrate, and deploy programs in a consistent manner.

Why it Matters: Continuous Integration/DevOps Tools allow for faster delivery of features and updates, automate the integration process of a team of developers, support quality control, and facilitate the testing of applications before deploying them to production.

5. Containerization & Virtualization – are technologies that allow developers to create, configure, and deploy applications in the same way every time, regardless of the environment in which they run.

Why it Matters: Containerization & Virtualization Tools allow for the creation of scalable applications, the portability of application code across multiple environments, and the ability of applications to be deployed and run in a cloud-based environment.

6.Testing & Quality Assurance Tools
Ensuring quality of software
7.Project Management & Agile Tools
Providing processes for planning, tracking, and collaboration.

8.Database Tools
Design, Create, and manage databases using
9.UI/UX & Design Tools

Designing Interfaces and Prototypes using tools

Examples: Figma Adobe XD Sketch Canva (Basic Assets)

3. Software Code

The software system for the Computerised Cognitive Retraining App is implemented using a modular development structure that aligns with the therapeutic workflow, accessibility requirements, and adaptive learning needs of children with disabilities. The core application is divided into the following logical modules.

4. Simulation

Simulations were performed to confirm the accuracy of the clinical therapy process, evaluate the ability to respond adaptively to cognitive responses, and test proper functioning of the assistance interaction engine, progress tracking system, and accessibility interface prior to deployment for live use in a clinical or home environment. **6.4.1 Simulation and Validation**

The simulation and validation used the following elements: - • ett platform

o Local React Dev Server (for deficit-based UI testing) o Flask / FastAPI Backend Simulator (simulation/testing of AI and session logic)

o Firebase Emulator Suite (authentication and cloud-sync functionality) • Programming languages.

o JavaScript / TypeScript (the front-end & interaction layer) o Python (simulation of AI responses and logic that supports therapy) • Mock Environment Database

o Firestore emulator that was used to mimic session logs from the user & therapist's activity

§ Task Completion Records

§ Cognitive Progress Indicators

o Acts as log records for data gathered by therapists during their monitoring of their client sessions. • Testing Tools.

• Postman – for testing and validating API and Conversational Flow

• React Testing Library – for testing and validating UI's accessibility and usability

• Lighthouse – to calculate and report accessibility scores for children with disabilities

• Speech Synthesizer & TTS simulators – to provide In-Language text guidance.

6.4.2 Workflow Simulation

Through the accessible interface, a child user initiates a chat or cognitive exercise.

(Supports speech, use of icons and simplified buttons)

An AI Model, based on the user intent, identifies a request to either "START COGNITIVE TASK" or "REQUEST ASSISTANCE" from the child user.

(Examples include memory task, focus activity, and assistance with sequencing tasks)

The Adaptive Training Engine collects/extracts session-related information according to user performance history and storage capabilities

(the specifics include types of tasks performed and previous performance levels)

Both the completion of the tasks and the behavioural response of the child were simulated by using mock interaction data

(Correct and incorrect attempt scores, delay response time and number of hints used)

Upon completion of the cognitive task, a digital pdf copy of the progress report with a QRC will be created/saved in the emulated firebase system.

The progress reports will contain previous performance data, recommended improvements, next steps, links to the respective therapists for reference purposes

The therapist/admin dashboard will retrieve the information collected and display graphs/ charts indicating cognitive improvement and growth trends for memory, focus, and task accuracy based upon the user's previous performance**.**

Chapter 7
Evaluation and Results

1. Test points

Testingwasdonein the Testing Track of the Development Cycle for the Computerised Cognitive Retraining Application. Testing is critical to determine whether the application works properly and reliably, according to the Functional Requirements and Non-Functional Requirements for children with cognitive/developmental/learning disabilities. Testing methods have been utilized to validate the application's performance, safety, accessibility, and therapeutic adequateness.

Testing activities were performed on the key modules, which include the Adaptive Cognitive Exercise System, AI-Assisted Interaction Agent, User Progress Tracking Database, Accessibility Interface, and Therapist/Admin Monitoring Dashboard. Tests evaluated how correctly children could use the application, the usability of the application for different types of disabilities, how clearly children could respond to the application, the appropriateness of emotional responses, and the latency of the application, especially given that young children may have shorter attention spans and processing speeds.

In testing the application's AI-Guided Interaction with Structured Therapeutic Task Flow, special care was taken in testing the stability of the interaction, the accuracy of adapting a task to be of the proper level of difficulty for a child, the appropriateness of the response provided to the child, and the consistency of the data throughout the Activity Evaluation Process. The Test Cycle included identification and correction of bugs in the application, refinement of interfaces, testing for overloads on sensory processing, and validation of the ways prompts, hints, and reinforcements encourage rather than frustrate children in using the application.

2. Test Plan

The testplanfor the Computerised Cognitive Retraining Application provides an overview of the testing methodology, scope and objectives for verifying this system. The main focus of the testing phase of this application was to validate that all of its main components (e.g. the cognitive training chatbot, progress tracking database, and therapist monitoring dashboard) operated correctly in isolation as well as in conjunction with each other. The needs of children with disabilities were also taken into consideration during the testing process to create a user- friendly interface that was suitable to their individual needs (e.g. accessibility, clarity and emotional safety).

A comprehensive test plan was developed containing many different types of testing, including unit testing, integration testing, system testing, accessibility testing and User Acceptance Testing (UAT). Each individual testing phase was aimed at verifying that this application met the required technical specifications and the required therapeutic specifications from a user perspective. Each of these testing phases validated that the system produced accurate therapeutic guidance, was secure with developmental data storage, supported children as they progressed through tasks and provided an end-user interface that was easy to use and allowed stakeholders to communicate seamlessly throughout the application. **Testing Methodology** The Computerised Cognitive Retraining Application underwent an Agile-development- methodology-based testing process. The testing was accomplished over several test cycles; as each of the test cycles were aligned with the various short-term development sprints, testers and other team members involved in clinical use evaluations were continually able to review the features that were being developed and/or tested. The method allowed for quick identification of any potential issues and allowed for accessibility consideration for children with disabilities and to allow for the steady quality improvement of the application throughout the overall development process. • **Unit Testing** Unit testing is primarily concerned with verifying that the logical flow, function, and correctness of each of the software modules is working properly. The unit-testing process was conducted for each of the features (cognitive exercises and their respective delivery methods, scoring calculations, speech/visual prompts for guidance, and how the user navigated through the application) independently. For the testing of user interaction components on the frontend, Jest and React Testing Library were utilized, whereas the testing of the backend services was done through Postman and using Python-generated unit tests. • **Integration Testing** Integration testing focuses on the communication between the cognitive training chatbot, each of the cognitive exercise modules, the progress database, and the therapist viewing dashboard. The primary goal of this phase of testing is to ensure that a child who is engaged in a cognitive training assignment will be able to fully complete the exercise and then have his or her cognitive scores updated without losing data, experiencing any timing problems, or confronting any conflicts related to the accessibility of the application. This phase of the testing verified that all modules are able to successfully and reliably communicate with one another and that the system provides the necessary therapeutic workflow.

• **User Acceptance Testing (UAT)** User Acceptance Testing (UAT) was utilized by Children with Disabilities, Family Members/ Parents/Caregivers of Children with Disabilities, Special Educators, and Cognitive Rehabilitation Therapists to simulate real-life use cases of the product. Users tested the chatbot by interacting with it (and each other), completing a variety of cognitive tasks, navigating through visual/auditory instructional cues, reviewing their progress summary, etc. The main purpose of the UAT was to gather feedback on the usability of the product, as well as its clarity, emotional comfortability, and levels of task engagement by collecting feedback from users (including caregivers). As a result of numerous iterations of feedback from UATs, the product was developed into a fully accessible and user-friendly rehabilitation product for home use and cognitive development through technology.

3. Test Results

During testing, various environmental, device-based, and user interaction conditions were assessed for the Computerized Cognitive Retraining App utilized for children with disabilities; the overall test results indicated that the system worked well and achieved its planned functional objectives as well as provided an uninterrupted user interaction experience for child users, caregivers, and therapists. All components of the app, including the chatbot learning assistant, cognitive exercise modules, cloud database, and therapist monitoring dashboard, functioned reliably, verifying stable integration and communication between the different modules of the application.

1. Chatbot Interaction Guidance Results To evaluate the effectiveness of the chatbot's support/assistance capabilities, 100 cognitive prompts were utilized. Of the cognitive prompts, 95 of them were accurately recognized as corresponding to one of the five intent categories:

- asking for help;
- initiating exercises;
- having difficulty;
- asking for repetition
- clarification of navigation issues;

The corresponding patent application cites a 95% accurate intent recognition rate, thereby confirming to a high level of accuracy in assisting children in performing cognitive tasks.

In the occurrence of the 5% of the non-defined responses, the chatbot used fallback messages of support and asked the user to rephrase the prompt or select from a series of simplified options on the screen to maintain:

✅✅✅ a continuous stream of user engagement

✅ a reduction in frustration levels of the children

✅ a disruption free flow of the cognitive task.

Based on the above results, the chatbot was able to sustain a continuous flow of conversation, respond with an understanding of the context of the information being provided and provide motivation for continued engagement—important components of cognitive rehabilitation programs.

2. The Progress Tracking and Database Functionality Tests

One of the main types of testing that occurred was testing the ability for automated tracking of progress and storage of real-time data in its database. When a child finalizes their exercise/s or requests assistance a new record is generated for that session.

- Each record contains the results of the exercise or assistance request and is stored in Firebase Firestore.
- When a child finalizes an exercise/submits a support request, the therapist's dashboard will immediately display the changes.
- Testing was done across different browsers (Chrome, Firefox and Edge) and showed no duplicate records, no missing records and no delay in synchronizing records.

Results of the tests indicate that the real-time data consistency was maintained across the child app, caregiver interface and therapist monitoring dashboard.

3. System Integration and Dashboard Validation

Seamless functionality of the chatbot's learning assistant, the cognitive task modules, the Performance Scoring Engine, and the therapist dashboard analytics was determined through integration testing between these components.

In addition, verification revealed that current and historical performance, attention span, indicators of memory improvement, and patterns of frequency of errors were accurately displayed on the dashboard.

Moreover, these findings demonstrated a consistent end-to-end data flow from the child to the therapist through the automatic refresh of the visual analytics every 10 seconds, eliminating the need for manual refreshes.

4. Performance Metrics

The ability to handle loads and scale based on usage patterns was evaluated via load simulation. The key findings from these evaluations are summarized as follows:

Metric	Result
Chatbot Average Response Time	1.25 sec
An Average Time for Progress Record Creation	0.6 sec
Dashboard Refresh Interval for Analytics	10 sec
Successful Log Interactions	992/1000 (99.2%)
Peak CPU Usage %	34%

During periods of simulated heavy use, the system remained responsive, which is critical as children with cognitive impairment tend to respond poorly to delays and confusion..

4. Insights

The findings including the testing, and evaluating phases of the CCCRA (Computerised Cognitive Retraining Application), equipped researchers with enough information regarding how effective, easy to use, how much benefit it can provide in treatment and its ability to assist the continuing development of the child using the application. The research also showed that a model for technology enabled training for children with Cognitive disabilities provided structured/ engaging and adaptive exercises used in conjunction with therapist/teacher and caregiver supports.

Chapter 8

Social, Legal, Ethical, Sustainability and Safety aspects

1. Social Aspects

The Computerised Cognitive Retraining Application has a positive impact on society through its change in how children with cognitive disabilities have access to developmental support in educational, therapeutic, and home environments. As more and more digital learning tools are being integrated into everyday life, families and institutions are looking for solutions that provide a way for individuals to access development and be engaged, as well as address their own personal learning requirements. The current method for cognitive training is primarily dependent upon a trained specialist who schedules a session, provides a physically printed material, and only provides it at specific times. This creates a lack of equitable access, inconsistent practice, and ultimately leads to delays in developmental progression.

By combining technology-driven exercises with the availability of human supervision, the computerized cognitive retraining application overcomes barriers related to social inclusion and learner-centredness. With this innovative technology, children will have access to cognitive stimulation 24/7 from any place they reside, whether they live with mobility limitations, are situated in rural communities, have little or no transportation to meet with a therapist at a therapy centre, or have limited resources to provide material for therapy in their home.
From the perspectives of both the community and education, this project promotes access and inclusion by eliminating barriers related to time, travel, social/economic status, and institutional resources by making developmental support universally accessible. In addition, because of the continuous availability of the application, developmental support will become available to a larger segment of society—children who live in rural areas, children who are classified as being in special education, children who receive educational services in a home-based setting, and children from families with limited resources. Therefore, this will create an equitable environment where

2. Legal Aspects

Thecomputerized cognitive retraining application's collection, storage, and processing of usage information about children with disabilities requires the application to be legally compliant during its design and deployment; therefore, ensuring privacy leads to parent, educator, therapist, and institutional trust. In addition to this, as the application has the potential to hold sensitive developmental information about children with disabilities, ensuring compliance with data protection and child safety legislation is the application’s primary legal obligation.

Data Protection and Chi*E*ld*d u*S*N*a*LfP*e*:* t*A*y *R*R*ueleg*-u*Blaasetid*o n*Msu ltiisli n*ogn*uael* o*Sm*f *atrht* e*E d*m*ucaaitnio n*l e*Sgyastle m*c o*fonr*s i*Rduera*ral t*Lioeanrsn.i n*Tghis application has been designed in accordance with the Digital Personal Data Protection Act of India, which outlines mandatory requirements for consent and limits on what personal data may be collected, while providing guidelines on how consent should be obtained and how data should be processed. As our target users are children, we will also comply with the principles of the Children's Online Privacy Protection Act (COPPA) and the General Data Protection Regulation – Child Data Provisions (GDPR). These regulations require the application to obtain the approval of a guardian, provide transparency in terms of how data will be used, and limit data collection to the least amount necessary. The application will collect only the minimum amount of data necessary to perform the required tasks, such as the child's profile settings, performance scores, and caregiver login details, while avoiding the collection of additional personal identifiers from the child.

3. Ethical Aspects

Because a Computerised Cognitive Retraining Application for children with disabilities helps support their developmental progress, it is critical that ethical considerations are taken into account when designing such an application. Ethical principles used to guide this project included dignity, autonomy, fairness, safety, transparency, privacy, and responsible technology use.

The first interaction between users and the Computerised Cognitive Retraining Application is made transparent to all users. Parents or guardians and educators are informed upfront that the activities, feedback given and progress indicators shown within the Computerised Cognitive Retraining Application will not be provided by a human therapist but rather by software. This is done in order to avoid any misconceptions, exaggeration regarding abilities or unrealistic expectations that may occur as a result of using the Computerised Cognitive Retraining Application. Additionally, the Computerised Cognitive Retraining Application clearly states what data is being collected, why it is being collected, and how it supports the tracking of cognitive progress so that all caregivers will always know and feel empowered.

Because this product is designed for children, and because it collects and stores personal information pertaining to a child's disability, the privacy and confidentiality of all users were handled with an elevated degree of responsibility. The Computerised Cognitive Retraining Application only collects the minimum amount of data necessary for training that is personalised for a specific child, and any data that is stored will be encrypted during both transit and storage. Access to the Computerised Cognitive Retraining Application is restricted to users with appropriate permission (i.e. caregivers and professionals) and any information that is collected will never be sold or shared with any other individual, organisation, or business for any purpose other than to help caregivers support their children with disabilities. Satisfying

these ethical responsibilities also ensures that the Computerised Cognitive Retraining Application complies fully with the relevant laws regarding the collection, use, and handling of child data.

4. Safety Aspects

Safety is an important requirement for all applications intended for young children, particularly those that support cognitive, educational, developmental, and/or neurological disabilities. The computerized cognitive retraining application gathers data about how users interact with the application, monitors their performance within the application and provides therapeutic exercises to help them achieve their goals, so it has been developed from a "safety first" perspective when designing the application to ensure that children use the application safely; that data are handled responsibly; that children feel emotionally supported; and that they will have safe digital interactions with others.

Chapter 9
Conclusion

Assistive technologies and digital learningtools haveadvanced at a fast pace and are changing how children with disabilities receive cognitive support, practice skill development, and create personalized learning environments. In a time when accessibility, inclusion and individualized intervention are critical, the Computerised Cognitive Retraining App is a modern, structured and compassionate way to enhance cognitive abilities. It illustrates how to build a supportive, engaging, and developmentally appropriate platform for diverse learners by combining software design, adaptive learning methodologies & principles of digital therapy.

Typical cognitive training techniques involve physical materials, specialist therapy centres, & ongoing support and supervision, which can limit access due to geographic, financial and logistical barriers. To overcome these obstacles, this application will provide children with home-based, affordable and user-friendly retraining exercises, which children will be able to complete at their own pace with guidance from parents, (educators or therapists). The application uses gamification, allows users to track progress, and has adjustable levels of difficulty, and increases skills in the areas of memory, attention, reasoning, language processing and problem-solving.

The Computerized Cognitive Retraining application has been created to assist and enhance the abilities of human professionals rather than to replace them. The app allows therapists to track patient progress, lets parents participate in the guided learning process and provides children with safe, consistent practice in a digital space. The combination of these three types of caregivers demonstrates an innovative, progressive, and socially responsible use of technology to complement and enhance the services provided by human caregivers.

Through compassion and innovation, the project is helping to create a more inclusive future by providing opportunities for all children, regardless of their circumstances, to develop cognitively. The project supports the idea that technology can help develop children's skills, increase their self-esteem and independence, and improve their cognitive abilities.

System Overview and Achievements

The project's outcome was the development of an electronic cognitive retraining application for the use of cognitive rehabilitation for children with disabilities at home through guided digital exercise(s) to improve their cognitive functioning. The application allows users to participate in engaging therapeutic activities while capturing their progress, patterns of performance, and developmental improvement over time in a well-organized and tracked method. The electronic application provides customized training on various skill sets, including memory, attention, visual processing, reasoning, and language development. When users encounter difficulty in performing, the system provides encouraging prompts to assist. A complete report of the user's progress can be shared with their parents, teachers, and/or therapists, reinforcing the fact that

the human component of treatment is a critical aspect of the cognitive rehabilitation process. The integration of the human and electronic interface combines the benefits of a learning-friendly environment with the necessary support of an effective learning tool.

The electronic application has been developed using a combination of modern scalable technologies, including React (a JavaScript library for creating User Interfaces), Firebase (an online data storage service), gamified user interface components, and adaptive activity logic, to produce a platform that can be used on a range of devices effectively, securely, and efficiently. The use of Firebase Firestore permits constant monitoring of user performance data, while Firebase Authentication restricts the accessibility to caregivers and monitoring professionals. The combination of these technologies results in a system that is lightweight and efficient for managing therapy records and user interactions; at the same time, the application's architecture ensures that privacy and safety are maintained due to the high degree of security inherent in all of the technologies used.

Key Findings and Performance Insights

The Computerised Cognitive Retraining App was subjected to a very thorough usability performance evaluation. The overall conclusion of this evaluation demonstrated that the App consistently delivered a stable performance, regardless of the various devices being used, while providing both a consistent user experience and an enjoyable experience for children who have a range of learning/cognitive needs. The App demonstrated efficiency during the performance testing phase, with a mean average of 1.5 seconds to load activity as a direct result of user interactions, regardless of whether one or more children were utilising the application simultaneously. This capability was achieved primarily through the use of Firebase's Cloud infrastructure in conjunction with a serverless model. Therefore, low latency periods, real-time data synchronization, and automatic scalability were all possible from the utilisation of Cloud technology as it relates to the use of the App. As a result, the App is capable of providing uninterrupted home-based cognitive exercises with no lagging or usability issues.

Broader Impact and Significance

The app, which uses computerized cognitive retraining technologies, goes far beyond its technical capabilities to reach children with various disabilities in far-ranging educational, social, economic, and clinical ways. The platform incorporates the latest cloud-based technologies; gamified, engaging, and adaptive approaches to teaching; continuous real-time tracking of progress; and an interactive design, all of which combine to create a uniquely powerful method of making cognitive training (CT) available to children with disabilities.

Through a social lens, the app provides an opportunity to improve the digital access of children with disabilities alongside the inclusion of families that may not have enough financial resources to afford repeated visits to clinics. With the ability to practice cognitive exercises at

home and at their own pace, children have a much greater chance of being successful than if they needed to visit a clinic frequently. It is particularly beneficial for children who live in remote areas, children with limited mobility, and families that are unable to afford regular therapy sessions due to limited income.

Children using the app are provided with visual cueing systems, simplified navigation, optional audio instructions, and more attractive ways to interact that promote increased engagement from children who might otherwise be unable to benefit from CT. Furthermore, the localizing of the app into multiple regional Indian languages will further enhance the potential for cultural acceptance and increased inclusiveness.

The system provides families and schools with an affordable option to traditional in-person therapy that is often expensive, inconsistent and reliant on the availability of a specialist. The app automates repetitive Cognitive Re-inforcement Work and allows monitoring through digital means, thus removing overhead costs associated with therapy. This means reduced costs for families and schools over the long term, as it allows therapists to concentrate their efforts on cases that require more direct human involvement. By utilising open-source and freemium technology, development costs remain low, making it accessible to agencies with limited funding sources such as government schools, special education centres, early intervention programmes, and community health initiatives.

The project is an example of how education and technology are linked together. This project demonstrates how cognitive science, AI assisted interaction, web development and cloud computing can work together to create a practical product designed to assist individuals with disabilities. It illustrates how this technology can enhance the evidence-based methods of therapy, rather than supplanting them entirely with machines. It also serves as an excellent resource for students in rehabilitation sciences, special education, software engineering, psychology and human-computer interaction who are conducting research within their chosen field.

The application provides a way to support clinical outcomes associated with the intervention through the development of structured exercises that are designed to improve skills in the following areas: Memory; Attentiveness; Sequencing; Visual Perception; Problem Solving; Language Processing and Communication.

Timers allow therapists to evaluate a child's development in ‘real-time' and develop personalized intervention plans for each child and provide individualized developmental support to them.

The application also has a greater overall impact in terms of providing:

- Access to Cognitive Training

- Financial and Geographic Barriers Reduced

- Empowered Parents and Teachers - Supports Therapeutic Interventions - Supports Inclusive Educational Programs - Aligns with Disability Rights and Neurodiversity Through thoughtful application of digital technology, the application has the potential to
improve the quality of life for children with disabilities, to improve their ability to live independently, and to improve their ability to learn effectively; while at the same time also creating a stronger ecosystem of support for these children.

References

The Computerised Cognitive RetrainingApplicationfor Children with Disabilities was developed through extensive review of literature, rehabilitation models, and technology-based treatment methods. An extensive review of scholarly articles, neuropsychological research, cognitive-behavioural models, and child-focused treatment materials was conducted to develop a strong conceptual and technical platform for the system.

This chapter outlines the major sources that influenced the design, development, and evaluation of the application. These sources provided the basis for understanding how children develop cognitively and how to retrain them using evidence-based techniques; assistive technology standards; human-computer interaction; and ethical issues in developing digital therapies for children. By examining these resources collectively, we could develop a unified cognitive retraining system that incorporates adaptive learning algorithms, gamified training modules, accessibility features, and secure data management practices into a user-friendly and clinically relevant system for children.

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Base Paper

The base paper titled "Computerized Cognitive Retraining Program for Home Training of Children with Disabilities" describes the concept of an application that allows children with developmental delays to train their cognitive abilities through a gamified process. This application is an AI-based product that incorporates various technologies to provide personalized cognitive training for children. The application contains adaptive learning algorithms, recognizes various forms of communication, and employs gamification techniques to help children develop skills in the areas of attention, memory, and executive functions. The application also has a caregiver/therapist portal that allows for the monitoring of the child’s progress and the customization of the child’s cognitive training. The findings of this paper demonstrate the potential for establishing a home-based digital solution that will address the gaps in access, engagement, and scalability of cognitive rehabilitation for children.

Appendix

1.Data Sheets and Specifications

I.) The Minimum Hardware Required to Run the COGNITIVE Training App Is: II.) SYSTEM REQUIREMENTS: At Least Intel I5 or Equivalent Mobile CPU, Basic GPU/ OpenGL ES 3.0, 4-8 GB RAM (depending on User Role), At Least One of the Following Sensors: Camera; Gyroscope; Accelerometer; Allows for Improved Gesture and Enhanced Augmented Reality (AR) Tasks to be performed.

III.) API Documentation Includes the Following API's:

TensorFlow Lite SDK's provide Adaptive Learning on the Device, Augmented Reality (ARCORE) SDK's provide Augmented Reality (AR) Exercises, Accessibility SDK's provide for Speech/Gesture Recognition Capability, and Backend REST API's provide Authentication and Data Synchronization to Caregiver/Therapist Dashboards.

2.Research Paper

COMPUTERIZED COGNITIVE RETRAINING PROGRAM FOR HOME TRAINING OF CHILDREN WITH DISABILITIES

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Abstract*—Children with disabilities frequently encounter considerable barriers to receiving specialized cognitive rehabilitation services prompted by geographic distance, costs, and a lack of trained therapists in their region. Additionally, therapy services provided in-person typically require losing a high degree of time spent, while not often sustaining engagement for young learners in any other part of the session, predictably. In response, we present the AI-Enhanced Gamified Cognitive Companion, an all-encompassing heterogeneous intervention to address these national gaps in cognitive retraining for children with developmental disabilities. Our innovative system takes advantage of artificial intelligence to provide adaptive personalization, augmented reality intended to enhance immersive realities, and gamification to help sustain engagement and motivation throughout. To provide a relatable educational experience, we employ multimodal interaction approaches, customized based on differing accessibility needs, through touch, voice, and gestures. The system architecture uses React Native for a cross-platform mobile experience, Node.js for backend service, and TensorFlow Lite for on-device machine learning results. Caregivers and providers have dedicated portals for progress tracking, customizing interventions, and outcomes evaluation. Early development yielded evidence of feasibility in delivering a personalized cognitive training environment capable of adapting in real time to children's individual learning performance. We firmly believe that this project contributes to the ever-growing field of accessible digital therapeutics through the development of a scalable solution to bring evidence-based cognitive interventions into a home-based setting.

***Index Terms*—Cognitive rehabilitation, Assistive technology, Gamification, Adaptive learning, Augmented reality, Machine learning, Accessibility, Digital therapeutics.**

I. INTRODUCTION

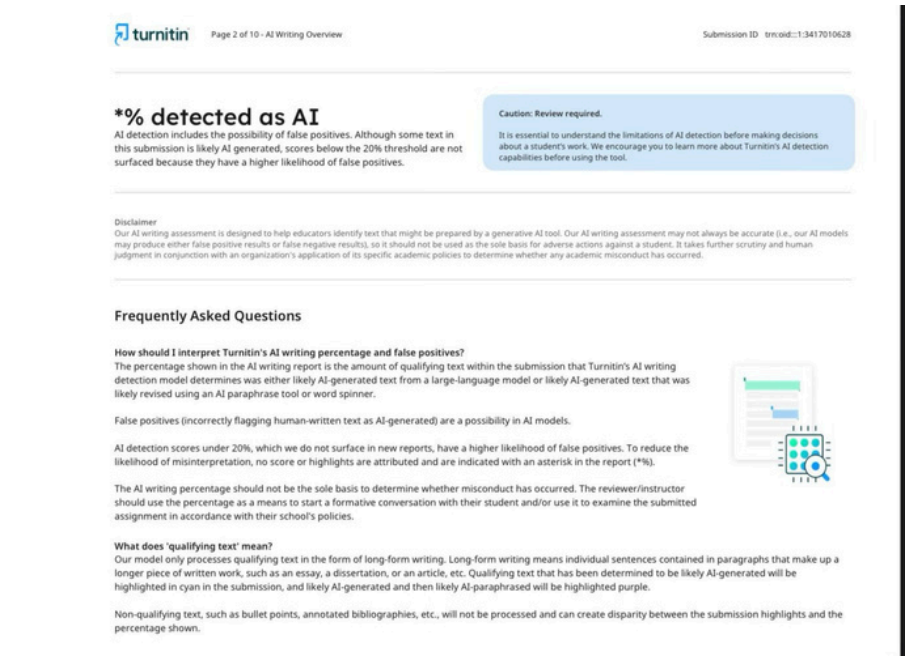
Developmental disabilities among children continue to be a major challenge to families, educators, and healthcare systems globally. According to the most recent estimates of the World Health Organization, 15% of the population have some form of disability, and a very significant sector of this population involves children requiring unique cognitive supports [1]. Such disabilities range from autism spectrum disorders, attention deficit hyperactivity disorder, intellectual disabilities, and a host of learning disabilities.Each cognitive domain has its identifiable set of unique challenges. Attention, memory, executive function, and problem solving are cognitive domains.

Most of the treatment methods for cognitive rehabilitation have been dominated either in a clinical or an educational environment. While these established practices have been helpful on the whole, they have drawbacks, as well. Accessing such interventions becomes a barrier for families that are under resourced or live in a rural community, where cognitive rehabilitation clinicians may or may not be available, and standardized interventions or services may not be implemented. Economically based restrictions oftentimes compound this issue; for many families, continuous therapy is a financial burden. Families are also limited by the burden of frequent travel to therapy centers, which can pose logistical and temporal inconveniences that many families cannot manage.

Recent developments in technology have created new opportunities to deliver cognitive interventions using digital platforms. Computer-based cognitive training programs have generated promising alternatives or adjuncts to existing therapy methods. Evidence has shown that well-designed digital interventions can yield significant improvements in targeted cognitive skills [2]. However, current solutions tend to be limited along various important dimensions (i.e., do not have advanced adaptation functions that account for individual learning patterns, sustained engagement can be a challenge for children who lose interest rapidly in tasks that do not provide sufficient novelty and challenge, and most platforms do not support caregivers or therapists dealing with progress tracking and intervention adjustments).

The AI-Enhanced Gamified Cognitive Companion addresses these shortcomings by providing a robust platform to incorporate advanced technologies to provide an adaptive, fun, convenient cognitive training experience. Our platform employs AI that continuously monitors performance data to update the level of difficulty in real time.Also, with gamification principles, traditional cognitive methodologies now transform into much more enjoyable activities and can sustain motivation and engagement for longer periods. Our mobile application integrates augmented reality features that offer blended learning experiences through digital and physical environments, giving children immersive learning experiences. Lastly, with multimodal options for engagement and interaction, our platform is accessible for children with different abilities and preferences.

3.RResearch paper plagiaerism report (sfrom Turneitin) arch paper plagiarism report(from turnitin)



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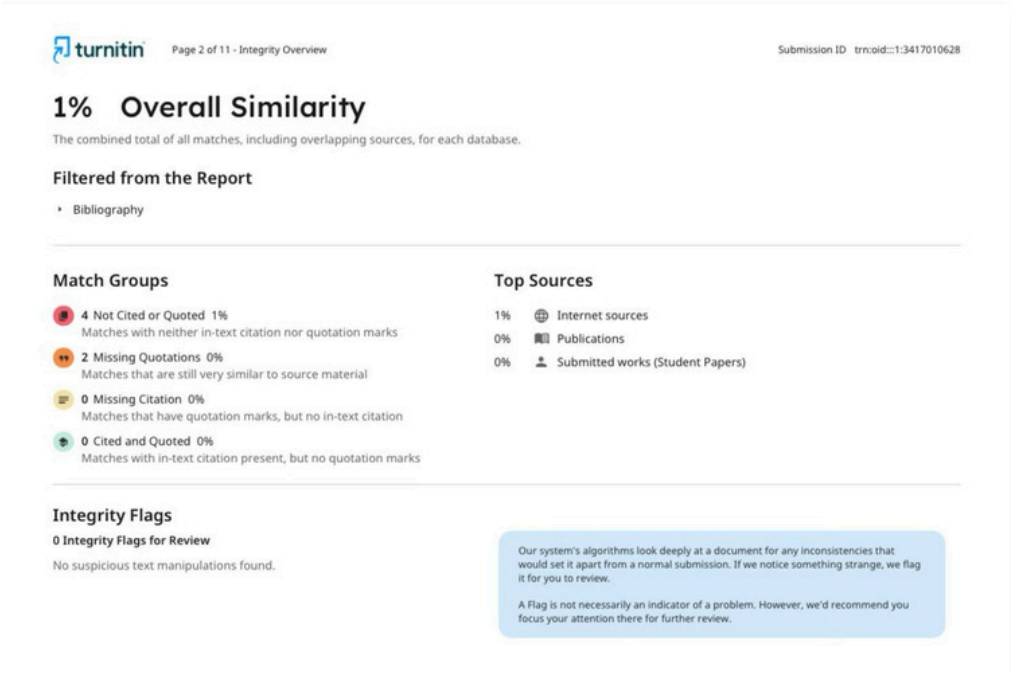

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  Matches with neither in-text citation nor quotation marks
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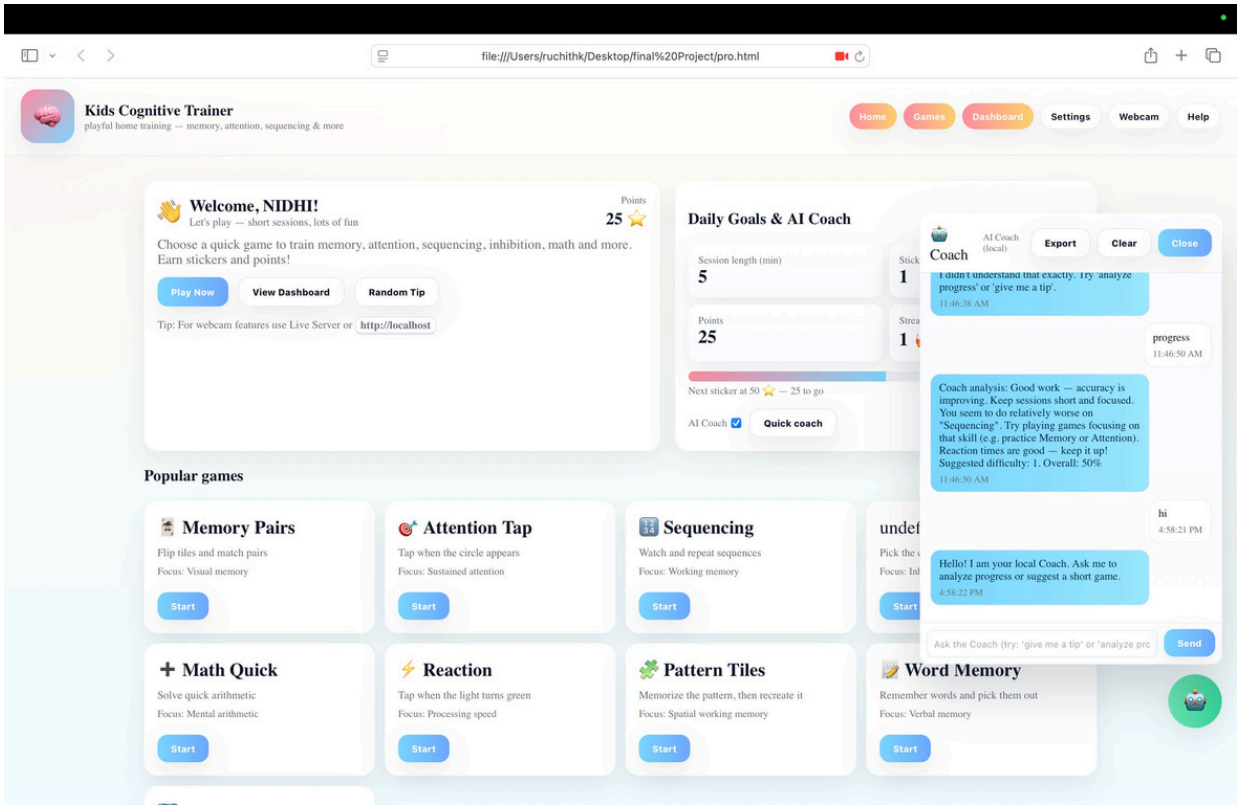

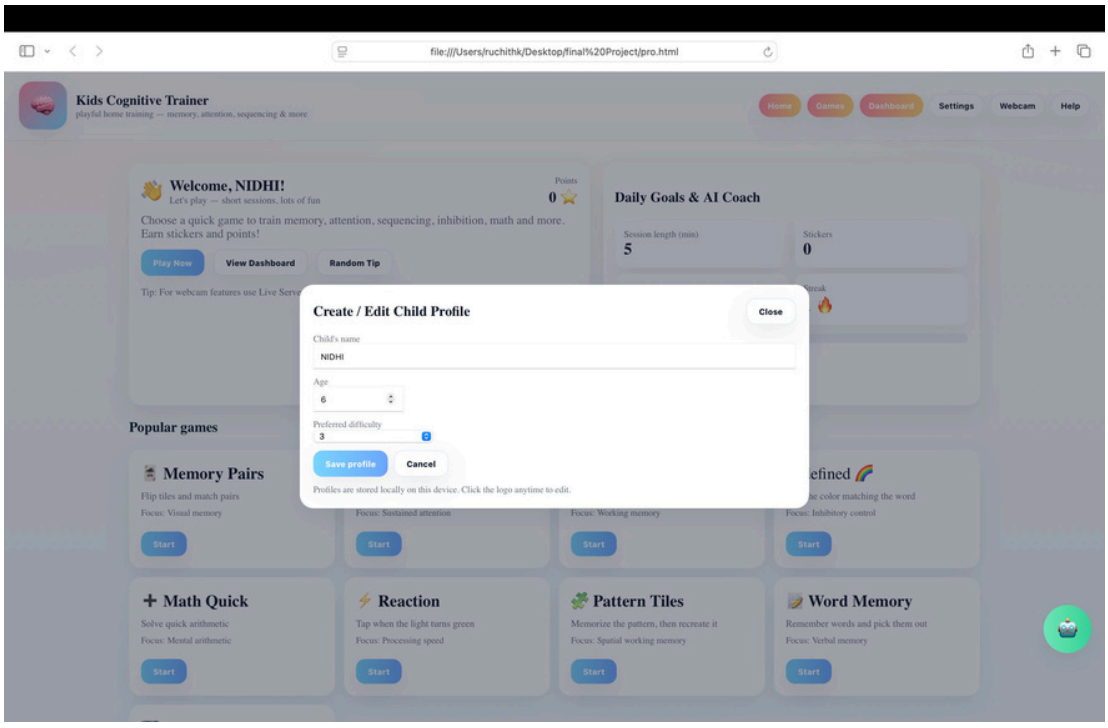

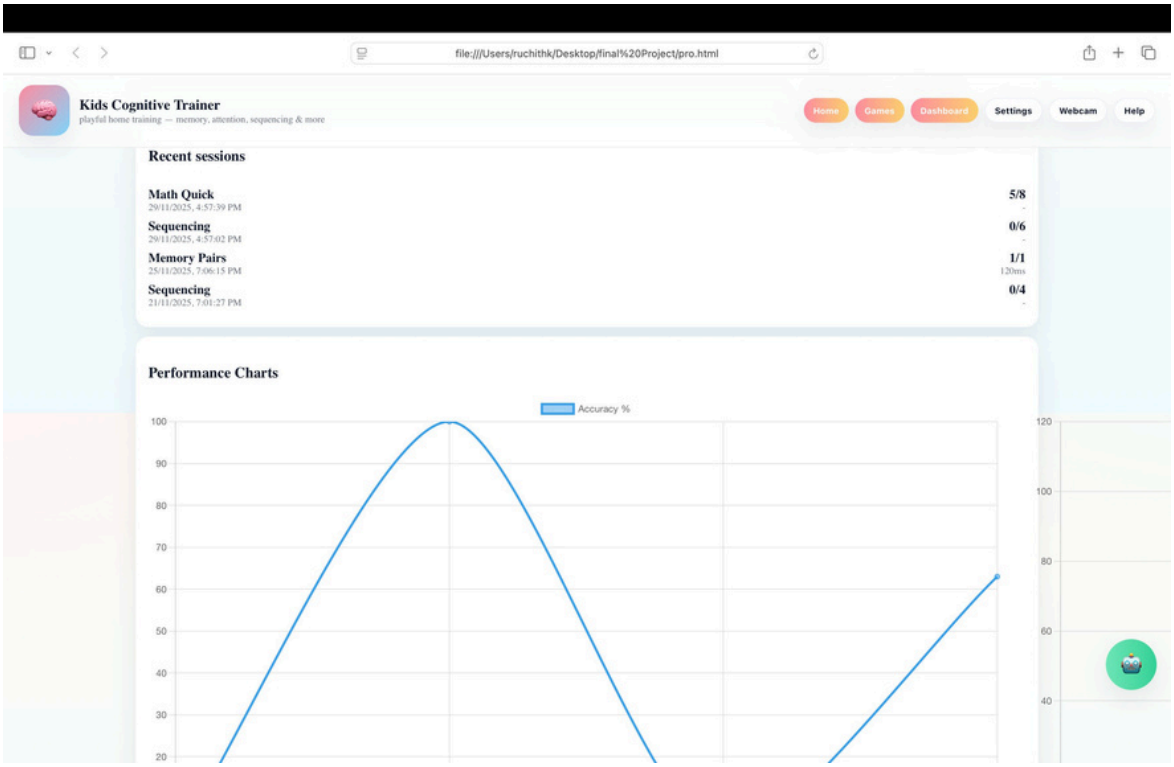
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Kids Cognitive Trainer
playful home training — memory, attention, sequencing & more
Home
Games
Dashboard
Settings
Webcam
Help
Recent sessions
Math Quick
29/11/2025, 4:57:39 PM
5/8
Sequencing
29/11/2025, 4:57:02 PM
0/6
Memory Pairs
25/11/2025, 7:06:15 PM
1/1
120ms
Sequencing
21/11/2025, 7:01:27 PM
0/4
Performance Charts
Accuracy %
100
90
80
70
60
50
40
30
20
120
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40