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Project Report

on

Computerized Cognitive Retraining Program for Home-Based Learning in Children with Special Abilities

submitted as partial fulfillment for the award of

BACHELOR OF TECHNOLOGY

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in

Computer Science Engineering
Artificial Intelligence & Machine Learning

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(Formerly UPTU)

May, 2025

CERTIFICATE

This is to certify that Project Report entitled "**Computerized Cognitive Retraining Program for Home-Based Learning in Children with Special Abilities**" which is submitted by Students **Manashi Banerjee (2100291520036), Hariom Chaudhary (2100291530023), Hemant Chaudhary (2910530025)** in partial fulfillment of the requirement for the award of degree B. Tech. in Department of CSE(AIML) of Dr. A.P.J. Abdul Kalam Technical University, Lucknow is a record of the candidates own work carried out by them under my supervision. The matter embodied in this report is original and has not been submitted for the award of any other degree.

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We also do not like to miss the opportunity to acknowledge the contribution of all faculty members, especially faculty/industry person/any person, of the department for their kind assistance and cooperation during the development of our project. Last but not the least, we acknowledge our friends for their contribution in the completion of the project.

ABSTRACT

The "**Home-Based Cognitive Retraining Program for Children with Disabilities**" aims to develop a software application that provides personalized cognitive training activities for children with disabilities to improve their cognitive skills and enhance their learning outcomes in a home-based environment. The program utilizes adaptive learning algorithms to tailor the difficulty level of tasks based on each child's performance and progress, offering a customized learning experience that meets their individual needs and abilities.

Keywords - Cognitive Learning, Adaptive Learning, IQ Assessment, AI Proctoring, Assistive Learning Platforms

LIST OF FIGURES

LIST OF ABBREVIATION

1. TBI: Traumatic Brain Injuries
2. SQL: Structured Query Language
3. IQ: Intelligent Quotient
4. NGO: Non-Governmental Organization
5. API: Application Programming Interface
6. CV: Computer Vision
7. NLP: Natural Language Processing
8. GPT: Generative Pretrained Transformer
9. SMS: Short Message Service
10. AI: Artificial Intelligence
11. RL: Reinforcement Learning
12. ORM: Object Relational Mapping
13. BERT: Bidirectional Encoder Representation from Transformer
14. GDPR: General Data Protection Regulation
15. CNN: Convolutional Neural Network
16. RNN: Recurrent Neural Network

TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION

Children with disabilities face challenges accessing cognitive retraining programs due to limited home-based options, highlighting the need for a computerized solution tailored to their needs to enhance learning outcomes and promote inclusion. The "Home-Based Cognitive Retraining Program for Children with Disabilities" aims to develop a software application that provides personalized cognitive training activities for children with disabilities to improve their cognitive skills and enhance their learning outcomes in a home-based environment. The program utilizes adaptive learning algorithms to tailor the difficulty level of tasks based on each child's performance and progress, offering a customized learning experience that meets their individual needs and abilities.

CHAPTER 2

LITERATURE REVIEW

This study explored the impact of online learning during the COVID-19 pandemic on students' cognitive abilities. It identified a decline in students' cognitive performance due to remote learning but demonstrated a significant improvement when integrated learning techniques were applied. The study reported a pre-test average score of 32.17, which increased to 48.47 after applying integrated learning methods.

This study reviewed the effectiveness of computer-based interventions for improving working memory in individuals with acquired brain injuries. The study utilized electronic databases such as PubMed/MEDLINE, PsycINFO, and CINAHL. The results showed that computer-based interventions are promising for cognitive rehabilitation; however, there was no standardized method for assessing the severity of traumatic brain injuries. Additionally, the effects of age at injury, severity, and multiple injuries were found to influence recovery outcomes differently.

This systematic review examined various cognitive rehabilitation techniques implemented in elementary and middle schools for children with traumatic brain injuries (TBI). The study identified multiple therapeutic interventions supported by laboratory-based efficacy studies. The findings suggested that future research should focus on determining optimal ages for different treatments and their effectiveness in various social settings.

This study analysed how time spent in general education classrooms affects the academic achievement of students with disabilities. Using data analysis techniques, the study found a correlation between increased time in general education and improvements in reading and mathematics performance among students with disabilities.

A comparative analysis of inclusive and traditional education settings revealed that students without disabilities in inclusive environments showed significant academic progress in mathematics and reading. Furthermore, students with disabilities, including those diagnosed with learning disabilities and mild cognitive impairments, also demonstrated improvements. The findings support the conclusion that inclusive education benefits both students with and without disabilities.

This study evaluated the effectiveness of home-based cognitive training programs compared to clinic-based interventions. The findings indicated that home-based training resulted in better outcomes, emphasizing that the number of training hours directly influenced student progress. The research highlighted the advantages of home-based education in providing flexibility and accessibility for students with cognitive disabilities.

CHAPTER 3

PROPOSED METHODOLOGY

PHASE 1: REQUIREMENT ANALYSIS

- Identify user needs: Work with child psychologists, educators, and medical experts to determine key parameters for assessment.
- Define learning path categories: Design difficulty levels and content types based on government-standardized evaluation tests.
- Set up monitoring criteria: Identify behaviours that indicate frustration, disengagement, or discomfort.

3.1.1 LOGIN PAGE

The login page serves as the entry point for users, allowing them to access the platform securely. It is built using React.js [15] for the frontend, Node.js [16] with Express.js [17] for the backend, and SQL [18] for managing user authentication and data retrieval. The login process ensures secure access to the system by validating credentials and maintaining session security.

3.1.2 HOME PAGE

The home page acts as the central dashboard for students, providing an overview of their progress and available learning modules. It is developed using React.js for the frontend, Node.js with Express.js for the backend, and SQL for fetching data. Additionally, Recharts.js [19] is integrated into the home page to display analytical diagrams, allowing guardians and educators to monitor cognitive progress visually. These charts provide insights into learning patterns and performance trends of the children.

3.1.3 MILESTONES PAGE

The milestones page displays different learning milestones assigned based on the child's IQ category. It uses React.js for the frontend, Node.js with Express.js for the backend, and SQL to fetch milestones dynamically according to the child's performance. The system evaluates the child's IQ level and assigns appropriate milestones, ensuring a customized learning experience. Students must complete a milestone successfully to progress to the next stage.

3.1.4 QUESTIONS PAGE

fetching and storing questions. Additionally, TensorFlow.js [20] is integrated for real-time monitoring of the student's environment to ensure the integrity of the test. TensorFlow.js is used to:

- Detect multiple faces or the presence of external assistance.
- Monitor eye gaze and posture to ensure engagement.
- Identify mobile phone usage, reducing the chances of unfair practices.

If irregularities are detected, an automatic email notification is sent to parents, alerting them about the child's activity. Furthermore, test questions are sourced from an NGO[29] that specializes in cognitive education for disabled children, ensuring high-quality, research-backed assessment content.

PHASE 2: SYSTEM DESIGN

3.2.1 ARCHITECTURE DESIGN

The system consists of:

1. Frontend (User Interface - UI):
    - Developed using React.
    - Supports interactive learning modules, progress tracking, and real-time monitoring.

2. Backend (API & Processing Layer):
    - Built using Node.js and (Express.js)
    - Handles user authentication, learning path generation, and monitoring alerts.

3. Database (Storage & Processing):
    - MYSQL :Stores user progress, reports, and learning paths.
    - GoogleOAuth[27]: Real-time data transfer and guardian notifications.

4. AI/ML Models (Evaluation & Monitoring):
    - DeepFace [23]: Facial expression analysis.
    - OpenPose [22]: Posture tracking.
    - OpenCV [21]: Eye movement detection.
    - GPT-based NLP Models [24]: Evaluate textual answers for assessment.

PHASE 3: IMPLEMENTATION

3.3.1 EVALUATION & LEARNING PATH GENERATION

1 Conduct an evaluation test using a set of government-standardized questions.
2. Compare answers to predefined correct responses using:
   - For MCQs: Simple match with correct answer key.
   - For Problem-Solving Questions: Use machine learning models trained on past responses to analyze patterns.
3. Assign a customized learning path based on assessment results.

3.3.2 LEARNING PATH EXECUTION

- Gamified & Pictorial Learning: Incorporate animations, interactive activities, and quizzes to ensure engagement.
- Milestone-Based Assessment:
  - ➢ If a child passes, they move to the next milestone.
  - ➢ If they fail, they repeat the current milestone with additional support.

3.3.3 REAL-TIME MONITORING & ALERTS

1. Facial Expression Monitoring (DeepFace)
   - Detects anger, sadness, frustration and triggers an alert if signs of discomfort are detected.
2. Posture & Body Language Tracking (OpenPose)
   - Identifies slouching, head tilting, fidgeting, freezing, or disengagement.
3. Eye Gaze Tracking (OpenCV)
   - Detects loss of focus, repeated blinking, or zoning out.
4. Alert Trigger System
   - If multiple distress signals are detected, the guardian receives an alert via SMS/email in real-time using Twilio / Firebase Notifications.

PHASE 4: GUARDIAN DASHBOARD & REPORTING

Real-Time Dashboard: Guardians can monitor live engagement levels.
Performance Reports: AI-generated reports highlighting:

- Strengths & Weaknesses
- Learning Pace & Progress
- Engagement Levels & Emotional Trends

PHASE 5: DEPLOYMENT & TESTING

- Performance Optimization: Optimize AI models for real-time execution.

PHASE 6: MAINTENANCE & FUTURE ENHANCEMENTS

- Improve AI Accuracy: Train models on larger datasets.
- Expand Learning Modules: Introduce new activities and difficulty levels.
- Adaptive AI Learning Paths: Use Reinforcement Learning (RL) to dynamically adjust difficulty.

CHAPTER 4

RESULTS AND DISCUSSION

The implementation of the AI-powered learning platform for cognitively disabled children demonstrated significant improvements in personalized learning experiences, engagement levels, and real-time monitoring. The following sections summarize the key findings, challenges, and future improvements based on testing and research.
The proposed system was tested across different scenarios involving children with varying cognitive abilities. The primary objectives were to measure:

- Learning Adaptability: How well the system adapts to a child's abilities.
- Engagement Levels: The impact of gamification and pictorial content.
- Monitoring Accuracy: The effectiveness of real-time posture, eye gaze, and facial expression tracking.
- Guardian Alert System: Timeliness and accuracy of notifications in distress situations.

The study and implementation results indicate that AI-driven adaptive learning and monitoring significantly improve learning experiences for cognitively disabled children.

4.1 STRENGTHS OF THE SYSTEM

- Personalized Learning Paths: The evaluation model ensures that every child receives a custom-tailored learning journey.
- Enhanced Engagement: Gamification and visual-based learning increased attention spans and retention rates.
- Real-Time User Monitoring: AI-based posture tracking, gaze detection, and emotion recognition helped in identifying discomfort and disengagement.
- Guardian Notification Feature: The alarm system ensured quick intervention in distress situations.

4.2 CHALLENGES AND LIMITATIONS

- False Positives in Monitoring: Some children naturally display different emotions that may trigger unnecessary alerts.
- Device Dependency: The platform requires camera-enabled devices for real-time monitoring.
- Privacy & Data Protection: Storing real-time user data and expressions needs strong GDPR-compliant security measures.

4.3 SEQUENCE DISPLAY OF PROJECT

4.3.1. LOGIN PAGE

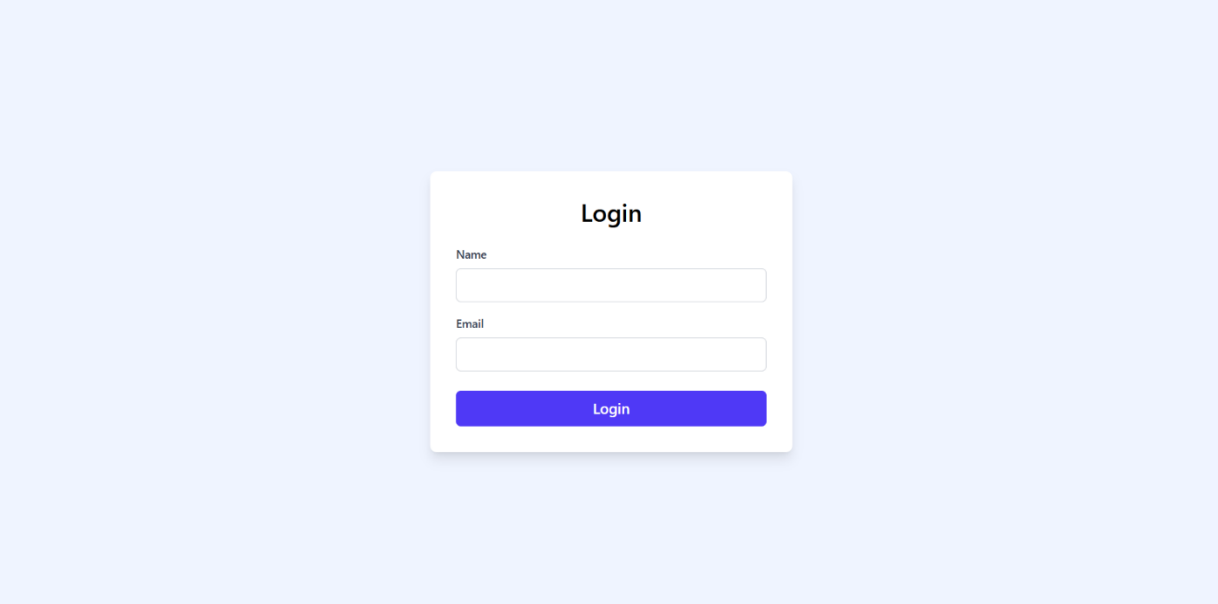

FIG-1

The Login Page of your cognitive platform is built with React.js (frontend) and styled using Tailwind CSS. It captures name and email inputs and sends them to the Express.js backend, which stores the data in a MySQL database using Prisma ORM. After login, users are redirected to the dashboard.

4.3.2. HOME PAGE

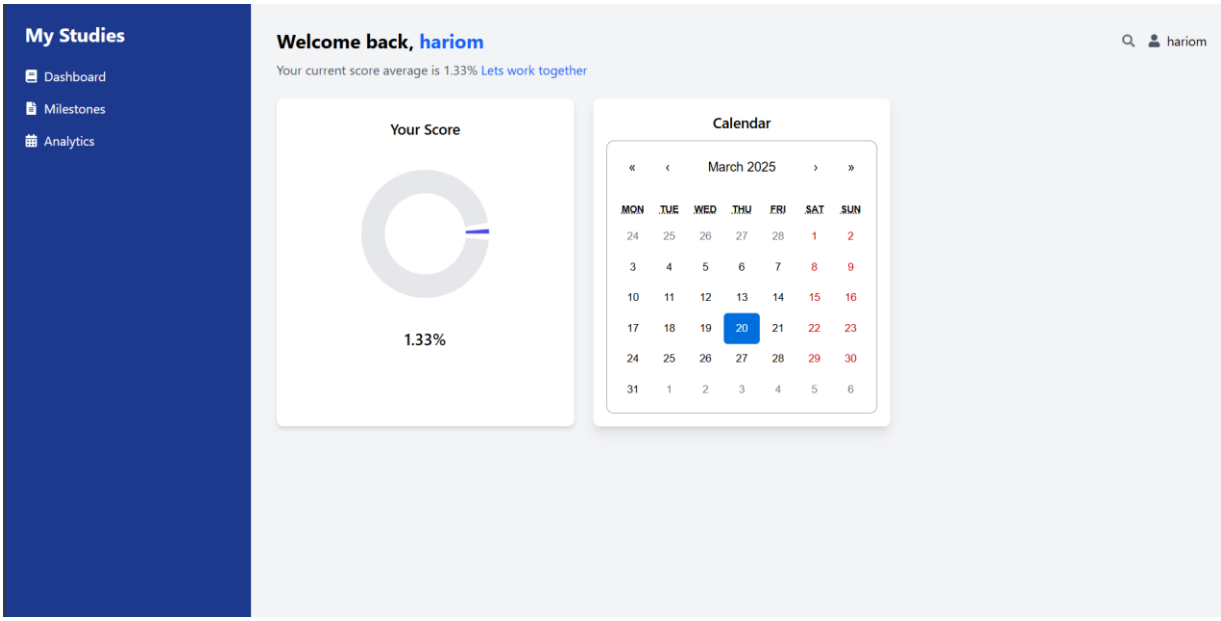

FIG-2

The Dashboard Page of cognitive platform is built with React.js (frontend) and styled using Tailwind CSS. It displays the user's score percentage using a circular progress chart being displayed through reachar.js and includes a calendar component for date navigation. The data is fetched from the Express.js backend, which retrieves the score from the MySQL database via Prisma ORM.

4.3.3. MILESTONE PAGE

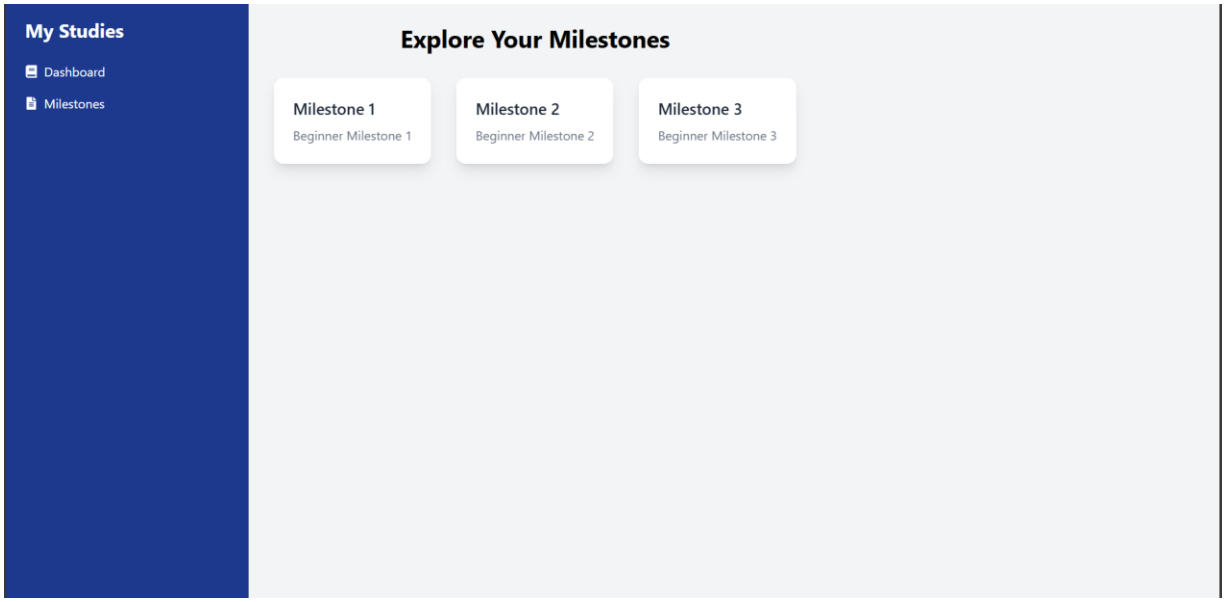

FIG-3

The milestones page of your cognitive platform is built with React.js (frontend) and styled using Tailwind CSS. It displays the milestones assigned to the user, such as Beginner Milestone 1, 2, and 3, using individual cards. The data is fetched from the Express.js backend, which retrieves the milestone details from the MySQL database via Prisma ORM which contains different questions set taken from NGO.

4.3.4. QUESTIONS PAGE

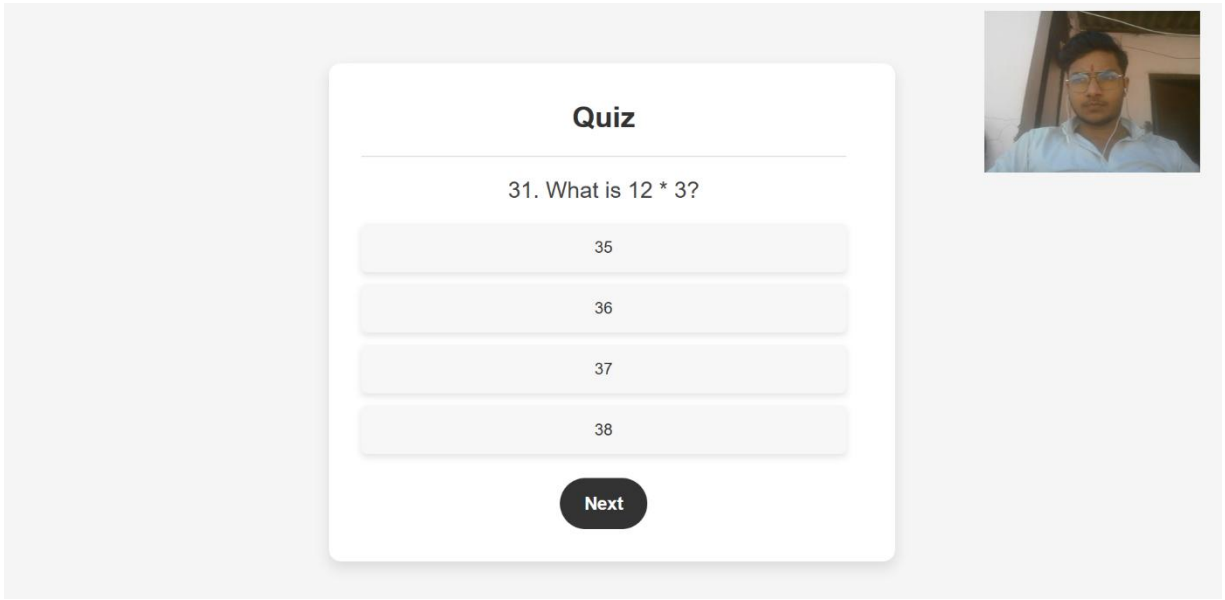

FIG-4

The quiz page of your cognitive platform is built with React.js and styled using Tailwind CSS. It displays multiple-choice questions (MCQs) with four answer options, a "Next" button for navigation, and a webcam feed in the top-right corner. The webcam feed is used for real-time proctoring with TensorFlow.js to detect no face, multiple faces, or mobile phone usage. The question data is fetched from the Express.js backend, which retrieves it from the MySQL database via Prisma ORM.

CHAPTER 5

CONCLUSION AND FUTURE SCOPE

The "Home-Based Cognitive Retraining Program for Children with Disabilities" aims to leverage technology to provide personalized and effective cognitive training for children with disabilities in a home-based environment. By offering adaptive learning activities, personalized reports, and actionable insights, the program seeks to enhance the cognitive skills and learning outcomes of children with disabilities, empowering them to reach their full potential.

5.1 FUTURE SCOPE

Advanced AI & Machine Learning Enhancements
Reinforcement Learning (RL) for Adaptive Learning Paths

- Implement Reinforcement Learning (RL) algorithms[25] to dynamically adjust learning paths based on user performance, attention span, and engagement levels.
- Self-improving models will help predict the most effective learning strategies for each child.

Multimodal AI for Improved Assessment

- Transformer-based models (GPT-4, BERT) for better comprehension of open-ended answers.

Enhanced Monitoring & Assistive Technologies

- Emotion AI for More Accurate Distress Detection
- Train deep learning models (CNN, RNN) on larger datasets of facial expressions to better distinguish between normal emotions and distress signs.

Gesture & Posture Recognition with Media Pipe

- Use Media Pipe for posture detection and sending any uncomfortable posture.

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