AI-Based Memory Curve Retention System Using Mobile Application

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Abstract

The digital learning process was growing rapidly and the main challenge faced by students is keeping the concepts in mind for a longer period, while traditional revision does not match human forgetting patterns. This makes performance go low and the study cycle ineffective. This paper proposes an AI-based Memory Curve Retention System which will remind or help learners revise at the right time through its mobile application. The system is based on Ebbinghaus's Forgetting Curve and implements intelligent scheduling when to forget a topic by making predictions about when the student is likely to forget the topic. On this prediction, personalized reminders in spaced-repetition intervals together with progress insights and analytics will be generated by the app, hence increasing memory retention and building strong revision consistency that can be tracked by the students on their overall learning progress, mobile interface, backend services plus structured database for storing topics, revision logs, and retention scores. Results demonstrate improved student engagement and better reinforcement of previously learned material.

Key Words: Memory Retention, AI-Based Learning, Mobile Application, Ebbinghaus Curve, Spaced Repetition, Learning Analytics.

1.INTRODUCTION

Irregular revision and lack of knowledge about when forgetting sets in are the main reasons for students' inability to recall what they had learned earlier. Pedagogy has proven that without systematic reinforcement, there is a drastic fall in the retention of memory. The Ebbinghaus Forgetting Curve scientifically proves how fast information can fade away from one's memory. However, students have not inculcated structured revision cycles because tools are not available to help them undertake the process consistently. The proposed AI-based Memory Curve Retention System shall beat this challenge with the help of intelligent prediction alongside spaced repetition. The mobile app observes how every student revises and comes up with suitable revision intervals that will strengthen long-term retention. This system is being developed so as to assist students in initiating a sustainable learning routine that matches natural memory patterns.

2. LITERATURE REVIEW

This section reviews previous works related to memory retention, spaced-repetition schedules, digital learning tools, and AI-based prediction models, with an emphasis on the gaps that our system tries to fill. Forgetting curve and foundational research. Early experimental work by Hermann Ebbinghaus resulted in the formulation of a principle whereby strength of memory decays exponentially over time without reinforcement. Subsequent educational psychology research added to Ebbinghaus's work by demonstrating that properly timed reviews drastically reduce forgetting and improve long-term retention. Foundational studies such as these justify the use of time-based review schedules rather than one-time study sessions. Algorithms and Practical Systems of Spaced Repetition. The forgetting curve is applied practically through spaced repetition by means of algorithms that schedule reviews at ever-increasing intervals (e.g., days → weeks → months). Some popular implementations include the SM-2 algorithm used by Super Memo and similar heuristics adopted by tools such as Anki and Memorise. These systems demonstrate that simple interval-adjustment rules, combined with user feedback (e.g., ease/difficulty ratings), significantly improve retention compared to unguided revision. However, classical algorithms typically rely on fixed rules and per-item ease ratings, which can be suboptimal for diverse learners and mixed content types.

Digital learning platforms and analytics.

Modern learning-management systems and mobile apps provide mechanisms for content delivery, tracking, and basic analytics (e.g., review counts, accuracy). Studies in learning analytics show that dashboards and performance visualizations help learners self-regulate study behaviour and instructors identify weak topics. Still, many existing tools stop short of deeply personalizing schedules using behavioural signals beyond simple recall correctness.

Machine learning approaches to retention prediction.

Recent research trends explore replacing or augmenting rule-based schedulers with data-driven models. ML approaches—ranging from logistic regression and survival analysis to recurrent neural networks—predict the probability that a learner will recall an item at a future time using features such as past response history, time since last review, response latency, and contextual factors (time of day, device). These methods can produce more accurate, individualized forgetting estimates, enabling adaptive scheduling that better matches each learner's retention dynamics**.**

Limitations in prior work and the niche for our system.

While spaced-repetition tools and ML models both show promise, gaps remain: (1) many apps do not integrate predictive models end-to-end in mobile workflows; (2) datasets used in academic studies are often small or domain-specific; (3) few solutions combine explainable predictions, easy user controls (e.g., manual overrides), and teacher/instructor dashboards for group-level monitoring. This creates an opportunity for an integrated mobile application that applies explainable ML predictions to schedule reminders, provides clear analytics to learners, and stores structured revision logs for research and improvement.

How our project builds on prior research.

Our AI-based Memory Curve Retention System combines the strengths of spaced-repetition scheduling with lightweight, interpretable predictive models and a student-centered mobile interface. Compared to rule-only approaches (SM-2, Anki-style), our system leverages behavioural features and short-term interaction signals to refine interval recommendations. Compared to pure research prototypes, our app emphasizes usability, signals to refine interval recommendations. Compared to pure research prototypes, our app emphasizes usability, offline support for mobile learners, and a structured database design that supports longitudinal analysis and teacher dashboards.

3. PROBLEM STATEMENT

Students experience poor retention of material studied previously due to infrequent revision, lack of reminders, and general inability to recognize when forgetting has occurred. Very few learning tools create personalized revision schedules based on one's memory decay pattern, leading to ineffective study techniques and reduced retention over long periods of time.

Poor revision consistency due to the absence of a structured, adaptive system makes learners revisit topics when it is either too early or too late. Apart from being very inconsistent with natural forgetting, this reduces learning efficiency and negatively impacts academic performance.

Therefore, there is a need for an AI-driven system that predicts the point at which a student will forget a particular topic by using the Ebbinghaus Forgetting Curve to send personalized and timely reminders. The system shall provide tracking of revision history and performance analytics to support students in building sustainable study routines on mobile applications.

4.RESEARCH OBJECTIVE

1. The key objectives of this research are:

2. 1. To design and develop an AI-based Memory Curve Retention System that can predict when a student is going to forget a concept based on the revision history of the student.

3. 2. Apply the Ebbinghaus Forgetting Curve and the principles of spaced repetition to generate optimal revision intervals.

4. Development of a mobile application that enables learners to add topics, track revisions, and receive custom reminders at scientifically pre-calculated intervals.To implement backend Analytics that measure memory strength, revision consistency, and topic retention scores.

5. Create a user-friendly dashboard that presents insights into performance, progress graphs, and retention analytics.

6. To assess the efficacy of the system in enhancing memory retention, revision regularity, and overall learning outcomes.

5. METHODOLOGY

The methodology adopted involves a structured, iterative development process, initiated through the analysis of existing learning challenges and the theoretical framework of memory retention. This involved designing the system architecture in a manner that would integrate a mobile frontend with a backend capable of storing user study patterns and computing scores for memory retention. At its core, the methodology lies in implementing an AI-driven logic stimulated by the forgetting curve, whereby each topic is assigned a memory value that gradually decreases over time. Whenever a user studies or revises any topics, this application will update the memory strength and will automatically recalculate the next ideal revision time. A combination of time-decay functions and data from user behavior is used to adjust prediction accuracy. Application interfaces are developed to remain simple and intuitive, thus making it accessible to students at different academic levels. The system logs the users' activity, generates analytical charts, and shows personalized revision timelines. This helps in continuous testing with sample users that refines the algorithm and ultimately ensures that the application successfully supports students in improving their retention and revision consistency.

6. SYSEM DESIGN

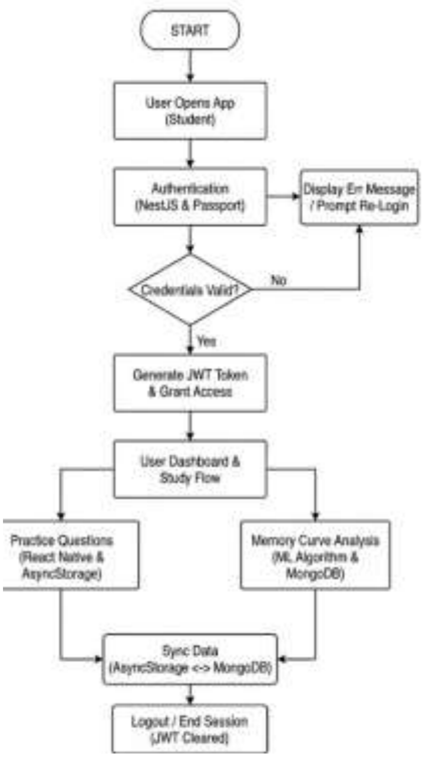

Figure 6.1 SYSTEM DESIGN FLOW CHART

The above flowchart depicts the comprehensive operational workflow of the AI-Based Memory Curve Retention System, showing interactions between the user, the mobile application, backend services, and the database components. This starts when a student launches the mobile application; it automatically initiates the authentication mechanism using NestJS and Passport for secure sign-in. If the user enters incorrect login credentials, the system shows an error message and will ask the user to re-authenticate to ensure that only verified persons gain access.

Upon verification of credentials, a JWT is created to authorize the session and securely grant access to the user's dashboard. The dashboard will then act as a main interface from which the learner will navigate through daily study tasks, practice questions, and recommendations based on memory. There are two major functional streams in this system: one handling practice-question interactions via React Native and Async Storage, and another handling memory curve analysis with machine learning algorithms integrated with MongoDB.

The app continuously updates learning data, including question attempts, revision logs, and retention scores between the local device storage (Async Storage) and the MongoDB cloud database during use. This guarantees continued access to progression records, even on unstable network conditions. Machine learning analyzes user revision patterns, forecasts the likelihood of forgetting certain topics, and recommends personalized revision intervals in accordance with the Ebbinghaus Forgetting Curve to further improve long-term retention.

The session may then end with the user logging out securely, in which case the JWT would be cleared from the system to prevent unauthorized re-entry. This structured design ensures a reliable, modular, and secure workflow while maintaining continuous synchronization between the front-end application and backend services. The integration of authentication, intelligent analysis, and seamless data handling within the system provides for a streamlined learning experience optimized for memory reinforcement and effective revision planning.

7. IMPLEMENTATION

7.1 CONCEPTS

The AI-Based Memory Curve Retention System implements its operation based on a few basic concepts that work in cohesion to provide students with a personalized and adaptive learning experience. It is principally based on the principles of cognitive psychology, more specifically the Ebbinghaus Forgetting Curve, which describes the way memory retention decreases over time if revision does not occur. By understanding this natural decline, the system makes an accurate prediction of when a student will most likely forget a topic and thus schedules a revision prompt at the perfect time. This prediction framework is further enhanced with machine learning techniques that observe individual learning behavior, revision intervals, accuracy in practice questions, and time spent on different topics. From this data-driven approach, it deduces a personalized memory-decay pattern for each learner.

The system incorporates concept learning in science, along with mobile-based application development to enable ease of access for students. The frontend has been designed to provide an end-to-end smooth experience in managing subjects, practicing questions, and receiving reminders. The architecture of the backend supports authentication, synchronization of data, and analytics generation. Secure login mechanisms have been implemented by using JWT-based authentication, which ensures that only verified users can access their personalized dashboards. The system will integrate databases on the cloud to store topics, revision logs, performance metrics, and prediction results so that seamless access across devices is enabled.

Another powerful concept implemented in the project is that of spaced repetition, which reinforces information at ever-increasing intervals. The system combines spaced repetition with machine learning-based prediction to ensure maximum long-term retention with minimal unnecessary revision. This hybrid concept ensures that students will only revise when necessary, preventing cognitive overload and promoting efficient study planning. All these concepts together create an intelligent, adaptive, student-centric revision platform that enhances learning effectiveness.

7.2 ALGORITHM

Step 1: User opens the mobile app and asks for permission.

Step 2: The system loads the authentication screen and prompts the user to log in.

Step 3: The user logs in with their credentials → Backend (Nest JS & Passport) verifies authenticity.

Step 4: If credentials are correct, a secure JSON Web Token called a JWT is generated → This allows the authorized access into the application.

Step 5: The user is taken to the dashboard where they can:

- Attempt practice questions.
- View learning progress and revision history.
- Receive reminders generated from memory-curve predictions.

Step 6: The ML-based Memory Curve Module performs the following:

- User performance analysis.
- Prediction of forgetting intervals.
- Generation of personalized revision timings.

Step 7: System syncs data between local storage (Async Storage) and the cloud database (MongoDB) to keep it consistent.

Step 8: The updated insights about the memory curve, performance graphs, and revision recommendations are presented to the user in a structured, interactive format.

Step 9: Finally, upon the user's logging out, the application will clear the JWT token and securely end the session.

7.3 FUNCTIONAL MODULES

The AI-Based Memory Curve Retention System is composed of several interdependent functional modules, each designed to support a seamless learning workflow while maintaining data accuracy and user-centric interaction. These modules work together to deliver personalized study recommendations, intelligent revision tracking, and secure application usage. The primary modules of the system are described below.

7.3.1. User Authentication Module

- Allows students to access the application using secure credentials.
- Validates identity using JWT-based authentication for secure communication.
- Displays appropriate messages when login fails due to invalid credentials.
- Generates a secure token upon successful login and clears the token during logout to ensure protected access.

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7.3.2. User Dashboard & Study Flow Module

- Provides students with an overview of their study progress, pending topics, and revision reminders.
- Allows smooth transition to practice questions, performance analytics, and memory curve features.
- Displays the student's learning pace and engagement using graphical summaries.

7.3.3. Practice & Question Module

- Enables students to attempt topic-wise questions that reinforce understanding.
- Uses Async Storage to temporarily store student answers and progress offline.
- Updates the system with timestamps of revision sessions to feed the memory curve algorithm.

7.3.4. Memory Curve Analysis Module

- Implements an ML-driven approach to estimate when a student is likely to forget a topic.
- Generates personalized revision reminders based on predicted retention drop points.
- Provides visual analytics, tracking long-term retention and improvement trends.

7.3.5. Data Synchronization Module

- Ensures two-way syncing between local storage (Async Storage) and the remote database (MongoDB).
- Stores user progress, revision logs, practice scores, and memory curve outputs securely in MongoDB.
- Automatically updates user records whenever new learning or revision activities occur.

7.3.6. Session Management & Logout Module

- Clears JWT tokens and user data securely during logout.
- Prevents unauthorized access by ensuring expired or invalid tokens cannot be reused.
- Confirms successful logout and redirects the user to the login screen.

8. TESTING

8.1. OVERVIEW

The testing phase will ensure this AI-Based Memory Curve Retention System works reliably, offers accurate recommendations, and provides a seamless user experience across devices. Testing aims to validate that every aspect of the application, from authentication and data synchronization to the memory retention algorithm, behaves as expected in a real usage scenario.

During this stage, all modules were assessed to identify functional errors, performance bottlenecks, UI/UX inconsistencies, and any integration issues among the mobile interface, back-end services, and the database. Testing the system iteratively ensures that user input is processed securely, revision schedules are calculated correctly, and data consistency between sessions remains maintained. The testing process will also verify whether the system adapts to changes in user behavior over time and provides accurate revision reminders, analytics, and predictions about the memory curve.

This phase provided important insights on application stability and robustness, making sure that the platform is dependable and user-friendly.friendly, and ready for deployment in a real student-learning environment.

8.2 TEST CASES

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Test Case ID	Test Scenario	Input	Expected Output	Result
TC01	Student Login with Valid credential credentials	Email & Password	Successful JWT token generation; User displayed	Successful login; dashboard displayed
TC03	User Login with invalid (Offline)		Spp coneth Password	Pass
TC04	User anestion Attempt (Offline Re-attempt Reden:Synge	Uet answered a locad to offline	Dmor: 5 local accuracy Rate ; Eod Re-attempt Reaton locally	Pass
TC05	Calculatt t Rate Rate (70/30 Weighted P09Δ)	Teo answery Ratec:lill%,	Displays etond-5 sync : 80% QuestionAttempt collection	Topic 'A attemts ted MONGOB Mmsthe8
TC06	Memory Power Score : for all Threshald	Uang download (80 x (50%) = 71%	(9' Acc 60%) Min attempt (69.855%)	Pass
TC08	Ebbinory Curve	Weak Topics	Good (302%)	Pass

ITC-Test Case]

Table 8.1: Test Cases

9. RESULT

The implementation of the AI-Based Memory Retention System showed very promising results in terms of enhancing the revision habits of learners and their overall retention levels. Once the spaced repetition algorithm was integrated into the application with personalized reminders, users were able to follow a more structured pattern of revision.

It analyzed user activities, estimated the predicted forgetting points, and prepared notifications in a timely manner to direct the learner back to the topic that was likely to be forgotten. Testing showed consistent performance in tracking study sessions, updating retention curves, and adapting the schedule according to user interactions within the application.

Graphical insights into the application, like visualizations of memory curves and progress summaries, allowed learners to gain insight into where their strengths and weaknesses lay. This increased self-awareness added incentives for users to regularly go through the study routines. Responses from the early adopters showed that the system makes revision less daunting and more organized compared to other modes of revision. On the whole, these results prove the practical efficiency of the proposed system for assisting students with improved memory retention and enhanced efficiency in studying.

10. CONCLUSIONS

The development of the AI-Based Memory Curve Retention System shows how technology can substantially improve the learning experience and help students adhere to effective revision patterns. The integration of the principles of the forgetting curve, along with a structured system for reminders, allows this application to ensure learners review information at the most appropriate intervals to maximize retention. The system successfully integrates user interaction, topic scheduling, and spaced-repetition logic into a single personalized learning assistant that adapts to individual study habits. Consistent reminders, performance monitoring, and an easy-to-use interface help to reinforce better academic discipline and improve long-term recall of concepts studied. In essence, the project has met its objective of making revision more scientific, organized, and efficient for students.

11. FUTURE ENCHANCEMENT

While the system works quite well as it is, there are some improvements that could significantly enhance its capability. Future models can have more advanced machine learning capabilities to predict forgetting patterns after considering long-term user behavior. Integration with external learning management systems, voice-enabled quizzes, and personalized study planning created with AI could extend the functionality of this system. Other analytics, like heat maps of strong and weak areas, allow users to more deeply understand their progress. Cloud storage and multi-device syncing will enable students to view their schedules with ease on any device. Building in badges, streaks, and rewards incorporates gamification elements that might further motivate consistent engagement. With these additions, this application has the ability to become a fully featured, intelligent learning assistant for students.

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