A Synopsis on

Spaced Repetition Based Adaptive E-Learning Framework

Submitted in partial fulfillment of the requirements
of the degree of

Bachelor of Engineering

in

Information Technology

by

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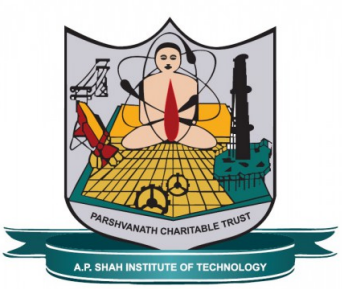

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CERTIFICATE

This is to certify that the project Synopsis entitled ***"Spaced Repetition Based Adaptive E-Learning Framework"*** Submitted by ***"Neelay Umrotkar (16104041), Varun Godambe (17104040), Amit Kharwal (17104045)"*** for the partial fulfillment of the requirement for award of a degree ***Bachelor of Engineering*** in ***Information Technology*** to the University of Mumbai, is a bonafide work carried out during academic year 2021-22.

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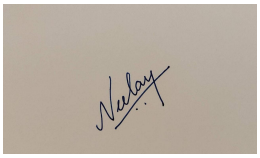

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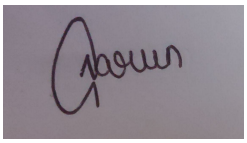

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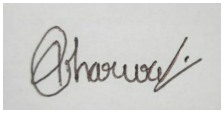

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Abstract

When it comes to academics, memorization is a big part of the system. Often times, students and it more difficult to memorize information. This results in the students not retaining the information effectively in the long term. A perfect example of this is students trying to rote-learn information a day before the exams. Even though this technique helps them clear the exam, it does not add to their knowledge.This is where our project idea comes in. We plan to make use of 2 emerging methodologies that help us memorize and retain information better in the long term. These are: Spaced Repetition: this helps in retaining information efficiently. Adaptive Learning: This will help us make the process of learning personalized.

Introduction

We intend to develop a system that helps students memorize and retain information in a systematic and efficient way. In order to do this, we decided to use techniques like Spaced Repetition, Adaptive Learning and in conjecture with these, we plan to add game like elements to keep the users' interest so as to not miss out on practice. Below, we've explained how each of these techniques mentioned above will play a part in our project.

Spaced repetition is a technique for efficient memorization which uses repeated reviews of content following a schedule determined by the spaced repetition algorithm to improve long term retention. We review information in the form of cards of information, at gradually increasing intervals. For example, if you answer a card correctly, the algorithm will repeat that card less frequently, whereas if you get the answer wrong, it'll be asked more frequently. Learning through rote memorization is tedious and ineffective.

Adaptive learning instead of a static and rigid learning system which forces everyone to follow the same learning pattern, you're given a personalized experience. If the learner takes a test, the algorithm can adapt the training according to the answers given. Doing badly on certain questions can trigger the system to push relevant content to the learner, or the overall performance could determine which learning path they take. Adaptive learning refers to measuring and responding to each activity while a student progresses in the material assigned by their instructor. When combined with data from student interactions, it is able to present the best content (right type, right amount, right level) for that moment in time to keep the student engaged. Flexible adaptive learning can help preserve the content regardless if you're teaching on campus, online or a mixture of both. Rooted in several learning science principles like spacing, chunking, and interleaving, create mini- cycles of questions that create smaller, easier to absorb chunks" of content. If students continue to struggle with a concept, they are more likely to encounter repeating questions.

Learning Curve: Two of the most common methods we see in the market are: 1) Pimsleur Method: Here you are asked to retain information learned after a predefined interval, without taking into account your performance in the previous review. This method is extremely restrictive and one-dimensional. 2) Leitner Method: Here, a few different intervals in terms of boxes, are predetermined. Let's say we have the intervals of 1, 2, 4, 8, and 16 days. Every new piece of information starts in the 1 -Day Interval Box. If the user remembers the information after 1 day, the information gets put in the 2 - Day Interval Box. If the user remembers the information after 2 days, it gets promoted to the 4-Day Interval Box, so on and so forth. If at any moment, the user fails to recall the information, then the piece of information gets shifted to the previous interval box.This method was a massive upgrade over the Pimsleur Method. But it can still be made even better by using another method.

For reference purposes, we selected Anki, a popular spaced repetition system. It is an open-source software that uses flash cards to aid in memorization. It is based on SuperMemo-2 which is a learning method that makes it possible to learn fast and retain memories for years. Using

Anki you can either make your one deck of cards or use from the over 750+ add-ons available in their database. One of the major drawbacks of Anki is that its app design is not very visually appealing, resembling pre-2000 windows.

To overcome this we propose the gamification of the memorization process, making it more appealing and also interactive. One such tool for gamified testing is Clozemaster. Clozemaster is a cross-platform for language learning which focuses on vocabulary building with the help of contextual learning." It is often marketed as the application you use after you're done using Duolingo," another language learning app that targets absolute beginners and aims to help them learn a language using the Leitner Method". The workings of Clozemaster are not something to be interested, however, the implementation of the idea along with all the various game-like elements is worth looking at. It features the following The very design of clozemaster is shaped in a way to make it feel like a game, even though what it tries to tackle is an advanced language learning problem. Elements that we found extremely necessary and helpful:

- Colorful Design
- Progress Bars
- Daily Goals
- Personal Stats
- Leaderboards

Objectives

We have identified the following as our project objectives:

1. To design an adaptive algorithm that takes user performance into account in order to adapt the next question's levels.
2. To design a space repetition algorithm that takes user's specific quiz performance into account.
3. To integrate Adaptive and Spaced repetition algorithms for the proposed system.
4. To add game design elements to make the layout appealing.
5. To create a cross-platform application interface.

Literature Review

In literature [1], the author focuses a significant chunk of itself on explaining the difference between personalized learning and adaptive learning, where, adaptive learning focuses on individual differences, individual performance and adaptive adjustment whereas personalized learning focuses on all of these but with the addition of personal needs. This here, makes a big difference. As our system focuses more on memorization and learning rather than teaching, one of the things we can adopt from this research is a feedback system which helps specialists and teachers cater to the student's needs better.

In literature [2], the author provides us with a primitive idea of how spaced repetition helps students perform better and how gamification helps to have students engaged during the process of learning and how it also helps them return to the process regularly which in turn also helps us understand just how effective spaced repetition is. We do plan to implement game-like features in our project to showcase similar results of engaging and retaining students to the learning process. We would also, as is regularly done with any spaced repetition program, expose students to maintenance and acquisition cards.

In literature [3], the author's model captures what the student has learned once a module is completed, and estimates how well he can recall this knowledge at any given time. Spaced repetition is a key component of the student model. Over time, the strength of a skill will decay in the student's long-term memory, and this model helps the student manage his practice schedule. The spacing effect is people remembering things more effectively if they use spaced repetition as opposed to cramming. We are given a brief exposure to primitive spaced repetition methods such as the Pimsleur Method and the Leitner Method. The main research that happens in the paper is related to the Ebbinghaus Forgetting Curve and how the researchers tweaked the original curve to make a model that more performs better when calculating the knowledge half -life. We will be using the Ebbinghaus Curve model to has our Half-life calculations on.

In literature [4], the author provides and details an adaptive learning platform which was implemented from scratch and used for undergraduate courses related to digital systems and computers. Students differ in their learning capabilities and it will be difficult to provide a tailored education, especially in large classes. Different technology solutions have been proposed to deal with this challenge. Rule based approaches use pre-determined branching architectures based on his response to questions. If a question is answered correctly, the system could issue a more challenging question which is pre-determined. The system can issue an easier question or hints or other assistance if the question is answered wrongly. Algorithmic mechanisms use mathematical models for inferring student's ability level perform real- time content adaptation. This paper helped us reinforce that adaptive learning does indeed help students memorize and learn better.

In literature [5], our takeaway is to increase the amount of content available for the user thereby reducing the chances of repetition in the same session while also removing the chances of the

user cramming all the content of the application in one go, thereby maintaining the integrity of the spaced repetition-based system.

In literature [6], the author focuses on the effects of adaptive learning in the domain of language learning and teaching. In adaptive learning, learner's interaction with previous content determines subsequent content. Hence a sort of personalization is seen. Digital flashcards are used to incorporate automated spaced repetitions of the targets learning item. Since the system is individualized, it can adapt relatively easily in response to small amounts of data. Stated to be a 'hot concept' that is 'poised to reshape education' in Webley magazine. As we intend to make the application based on digital flashcards, we can use the idea of creating algorithms to determine the order, frequency and difficulty of the next learning item based upon their previous exposure to it.

Problem Definition

Problem Identified: Learning is a lot of the times based on memorization. This can be especially difficult for people to achieve easily and leads to cramming and other ineffective short-term methods which can damage the learning process and are generally ineffective.

Proposed System Architecture/Working

In our enhanced Spaced Repetition based Adaptive Learning Framework, we start of with the user being showed a flashcard. The user has been assigned default values of SDS and Interval. And the questions have the value of DL. Once shown the flashcard, the user has 3 options: Retry: If the user selects this option, first, his SDS is reduced by 1. Next it is checked if the SDS is equal to Zero. If it is, it means that the user hasn't been able to answer 5 questions of the same difficulty. In short, the questions are too difficult for him. In this case, the DL is reduced by one to ease the user and the SDS returns to 1. Now, new cards of the reduced difficulty are produced. Difficult: Here, if the user selects this option, the interval is calculated using our half-life calculations based on Ebbinghaus' Forgetting Curve equations and the SDS is increased by 0.5. Easy: Here, if the user selects this option, the Interval is again calculated using the half-life formula and the SDS is increased by 1. In both Difficult and Easy options, if the SDS is equal to 5, the DL is increased by 1 thus producing new questions that are more challenging in nature to keep the user challenged.In our implementation, we use the half-life calculations to adjust the time intervals according to the needs of every individual. Another objective we want to achieve is a design that keeps the user engaged. Fig. 3. For this we

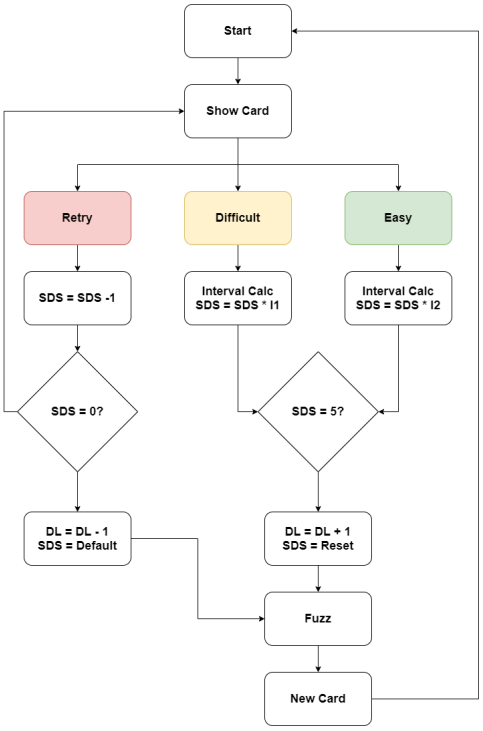

Figure 1: Proposed System Architecture

decided to add game-like elements to our interface. Surface level designs that help us retain users. For this, we plan to implement the following elements:

- Leader boards (Local and Global): Here the user will be able to see how they match up to the local and global high scores. This will help them keep motivated.

- Friend's List: Here the user can see their friends. On clicking on their profile, they can see an overview of how their friends perform as compared to themselves.
- Statistical Analysis Page: Here the user can see their performance on different
- scales across all their subscriptions. Suggestions will also be provided such that the user can improve.
- Progress Bars: Here the user can see a summary of how far they've completed various topics.
- Achievement Awards: For every milestone, users will be awarded an award. This is a positive reinforcement technique that will help students be consistent.

The interval is decided on the basis of how the user responds with their selection of a difficulty with regards to the question they face. Following the Forgetting Curve mapping by Ebbinghaus, we decided to stick to major milestones on the timeline as the interval progression. As shown in the table below, we start with the first repetition after 18 minutes of going over the card for the first time. This is followed by a repetition after 1 day, which is then followed by a repetition after 6 days, 30 days, 90 days and finally 180 days at which point of time, the interval continues to be 180 days. The basic structure follows that of the proposed infrastructure wherein the user is presented with 3 different difficulties and further repetition-interval calculations are done depending on the difficulty chosen. Retry: if the user selects this option, first we check if the current interval is equal to the minimum interval which is 18 minutes. If it is, the interval will continue to remain 18 minutes till the next repetition. If the repetition is not the minimum 18 minutes, the interval will be demoted to the previous interval. For example, if the currernt interval is 30 days, it will be demoted to 6 days. Difficult: If the user selects this option, there will be no changes in the interval. It will remain the same. Easy: If the user selects this option, first we check if the current interval is equal to the maximum interval which is 180 days. If it is, the interval will continue to remain 180 days. If the repetition is not the maximum, the interval will be incremented to the next interval. For example, if the currernt interval is 30 days, it will be incrememted to 90 days.

Design and Implementation

Although the implementation is currently work in progress, we do have a basic design ready that we have created on AdobeXD. It is as follows:

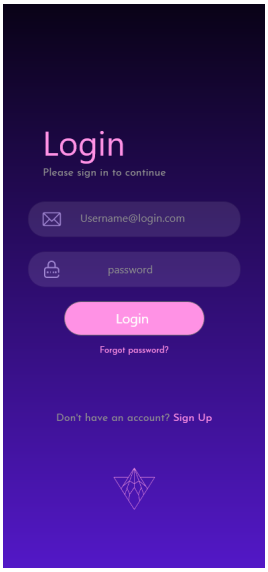

Figure 2: Login Screen

Here, we can see the Login Screen. It will be a 2D login screen with all the bells and whistles like Sign-up/Register section and also Forgot Password screen.

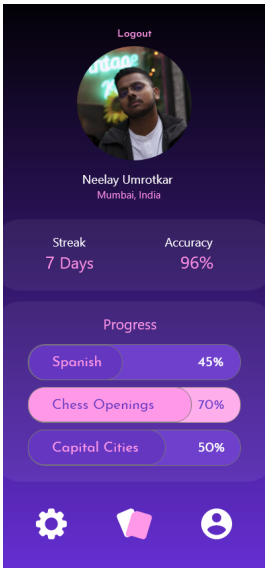

Figure 3: Profile Screen

Here, we can see the Profile Screen. It is loaded up as soon as the user logins. Here, we can see the profile picture that the user can edit. Their "streak" referring to their consistency, Their accuracy with their quizzes, and also basic stats on specific deck completion.

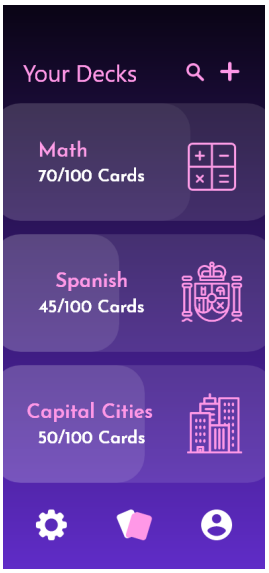

Figure 4: Home Screen

Here, we see the Home Screen. Here, the user's decks are displayed with basic completion stats. Along with it, we have also added a search function for the user to search for new decks.

Figure 5: Flashcard Screen

Here, we see the flashcard screen. It is a simple material deck that will show the user

questions to which he can respond by selecting one of 3 options given below. Upon selection, the algorithm will act accordingly to provide the next sequence of steps.

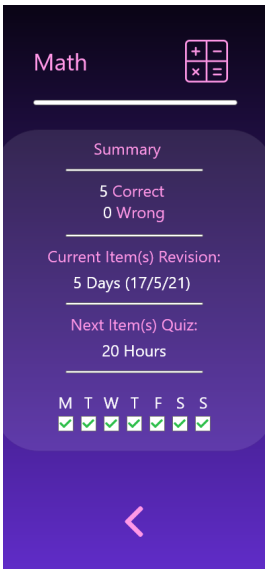

Figure 6: Post Quiz Summary Screen

Here is the Post-Quiz Summary screen. This displays basic details about the current deck quiz. It showcases the user's performance and informs them about the next time they'll be quizzed.

Summary

To summarize, we propose a new system that aids in memorization and learning with the help of spaced repetition, adaptive learning and game-like elements. The spaced repetition algorithm will feature better interval calculations with the help of the forgetting curve calculations based on the Ebbinghaus Forgetting Curve research. The more accurately spaced the intervals are, the more effective the spaced repetition algorithm will be. The adaptive learning will help the system take the best route that helps the user achieve their goals faster. Based on the user's performance, the system will adapt to either lower or increase the difficulty of the questions to make sure that the user doesn't find the questions easy, but at the same time doesn't find it too difficult either. Keeping the user challenged just the right amount is the key to a better learning experience.Game-like elements will ensure the user's experience is always fun and competitive. Elements like leader-boards, scores, personal profiles, performance statistics, achievement awards, etc are some of the elements we intend to implement.

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Publication

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