OCR A-Level Computer Science NEA

AI Flashcards App for iOS

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Contents

1 Analysis

1.1 Introduction to the Problem

As a Sixth Form student revising for my A-Level exams, I've personally experienced how difficult it is to find a truly efficient and engaging method of revising large volumes of content. I often found myself copying notes back and forth or trying various study apps that promised to improve memory retention but rarely delivered. Most lacked either flexibility, intelligent feedback, or the ability to integrate with the types of notes I actually use, like PDF handouts or typed summaries. The idea for this project was born out of my own frustration and a genuine need for a smarter solution.

The problem I aim to solve is how to help students revise more effectively by converting their existing notes into smart flashcards and providing interactive, adaptive study tools, all within a seamless and elegant iOS app. Unlike traditional flashcard apps, mine will incorporate AI to dynamically generate questions from documents, use spaced repetition algorithms, and even offer audio-based revision via mini podcasts. This not only makes revision more effective, but also more accessible, whether a student is revising on the bus, walking home, or stuck in a queue.

1.2 Why This Problem is Solvable Computationally

This problem is highly amenable to computational methods because it involves repetitive data processing, structured information handling, and user-personalised feedback loops, all of which are tasks that computers excel at. Computational approaches offer scalability, consistency, and the ability to integrate intelligent automation across the entire study workflow.

For instance, natural language processing (NLP) algorithms can be employed to parse and understand the semantic structure of uploaded notes, textbooks, or web content. These algorithms can identify key definitions, concepts, and question-answer pairs, which can then be automatically converted into flashcards. This removes the need for users to manually create decks, a time-consuming process, while also improving consistency in formatting and content quality.

Databases can efficiently store, organise, and manage large volumes of flashcards, user accounts, and learning sessions. This ensures that user progress is tracked accurately over time, and that study material can be retrieved instantly across devices. Backend systems can handle multiple concurrent users and scale with demand, something manual systems cannot achieve.

Spaced repetition algorithms, such as those based on SuperMemo's SM2 or more modern adaptive techniques, rely on real-time data about user performance. These algorithms can calculate optimal intervals for reviewing information, dynamically adjusting based on how well the user remembers each card. Implementing such logic computationally enables truly personalised learning experiences, something infeasible to deliver manually at scale.

Additionally, computational methods make it possible to integrate features like text-to-speech, AI-generated summaries, and auto-created podcasts, allowing users to engage with content in multiple formats. These techniques rely on large language models (LLMs), machine learning, and media generation tools, all of which are built on programmable, scalable systems.

Finally, the problem itself is defined and constrained in a way that suits computational modelling. Inputs (e.g. notes, user answers) are structured or semi-structured, and the desired outputs (e.g. flashcards, study reminders) follow predictable patterns. This makes it feasible to encode the logic as software that can process inputs, make decisions, and generate outputs autonomously.

1.3 Stakeholder Analysis

Primary Stakeholder: Chris Chan

Chris Chan is a Year 13 student preparing for his A-Level's. He is highly motivated but struggles with organising his revision efficiently. Chris relies on a mix of handwritten notes and PDFs from teachers, and often uses his iPhone to study on the go. His main goal is to maximise retention without spending hours rewriting notes or creating flashcards manually. Chris will use the AI Flashcards app to automatically convert his PDF/Word notes into flashcards, track his learning through spaced repetition, and revise via short audio summaries while commuting.

Secondary Stakeholder: Dr. Alice Morton

Dr. Alice Morton, a Computer Science lecturer who works closely with sixth-form outreach programmes, regularly recommends digital tools to help students improve their independent learning. She is especially interested in how artificial intelligence can support spaced repetition and knowledge retention. Her perspective helps ensure the app remains grounded in evidence-based learning principles and is suitable for academic endorsement.

Tertiary Stakeholder: Mr. Simon Webb

Mr. Simon Webb, a parent of two teenagers studying for their GCSEs and A-Levels, is invested in ensuring his children use mobile technology productively. While he doesn't use the app directly, he represents the wider group of parents who value tools that encourage consistent revision habits and help reduce passive screen time. Feedback from users like Simon informs design decisions that promote healthy and educational smartphone use.

These stakeholders will use the app to either support their own learning (Chris), enhance their students' outcomes (Alice), or evaluate effectiveness (Simon). The design prioritises ease-of-use, accessibility, and focused content delivery.

1.4 Analysis of Existing Solutions

1.4.1 Anki

Anki is a highly popular, open-source flashcard application that has gained widespread acclaim in educational and professional communities for its robust and scientifically validated approach to spaced repetition. At its core, Anki employs an advanced algorithm based on the SM-2 spaced repetition system, originally developed for language learning, which schedules flashcard reviews at optimally spaced intervals to maximise long-term retention and minimise forgetting. This evidence-based approach is backed by extensive cognitive science research on memory and learning.

One of Anki's standout features is its exceptional customisability. Users can create highly personalised decks with support for rich text formatting, images, audio, video, and even custom card templates using HTML and CSS. This flexibility allows learners to tailor flashcards precisely to their needs, whether they're studying languages, medical terminology, engineering concepts, or historical facts. Furthermore, Anki supports extensive add-ons created by a passionate community, which can enhance functionality ranging from user interface improvements to detailed progress analytics and new learning modes.

Anki is available on multiple platforms including Windows, macOS, Linux, iOS, and Android, allowing users to synchronise their progress seamlessly across devices. Its open-source nature means that it is continuously improved by contributors globally, ensuring a vibrant ecosystem that keeps pace with emerging learning technologies and user feedback.

Despite its many strengths, Anki has a somewhat steep learning curve, particularly for new users who may find its interface and numerous settings overwhelming. However, this complexity is often outweighed by the power it offers dedicated learners who want to optimise their study routines and engage deeply with their materials.

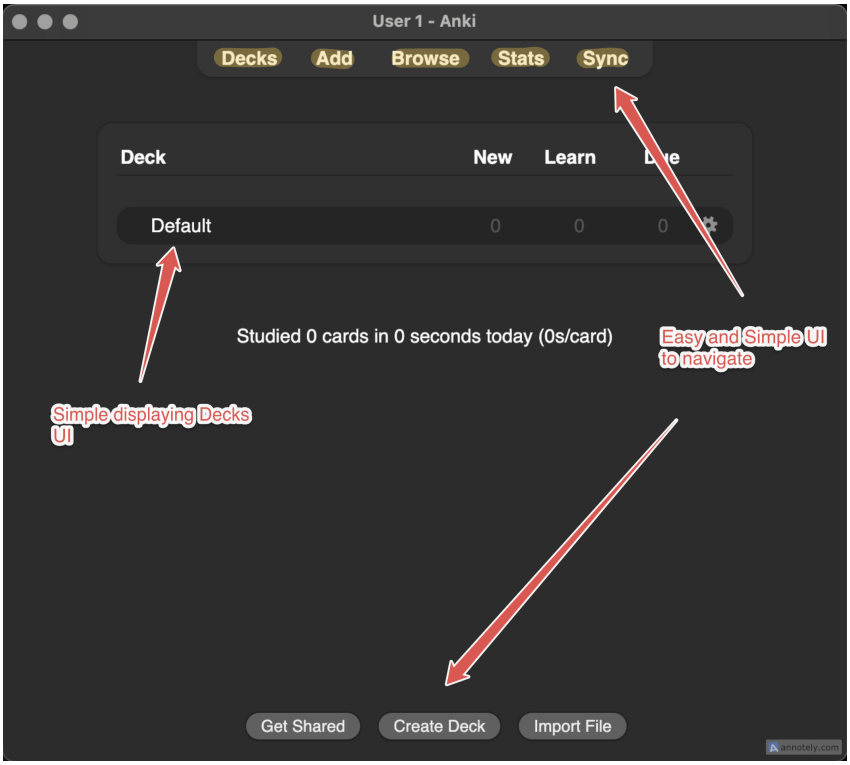

Figure 1: Anki Home Menu — shows the deck list and overall navigation

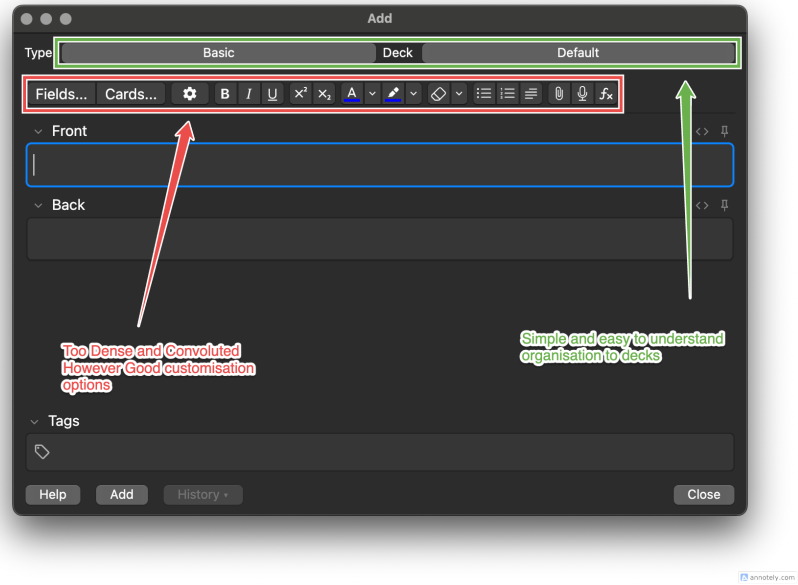

Figure 2: Anki Flashcard Menu — interface for creating and editing flashcards

Table 1 summarises the key strengths of Anki, including its core spaced repetition algorithm.

Table 1: Anki Features to Keep and Adopt in AI Flashcards App

Feature	**Why I Like It in Anki**	**How AI Flashcards App Will Use/Improve It**
Proven Spaced Repetition Algorithm	SM2 algorithm is research-backed and effective	Will implement an adaptive algorithm inspired by SM2 with added AI for confidence-based adjustment*
Rich Media Support	Supports images, audio, video for rich flashcards	Will allow embedded audio, images, and AI-generated podcasts for multi-modal learning*
Cross-Platform Availability	Desktop, iOS, Android versions available	Will support native iOS app plus web with offline sync*
Open Source	Transparent and modifiable codebase	Plan to keep open development with community contributions*
Extensive Customisation	Many settings for advanced users	Provide sensible defaults but allow power users to customise*
Large Community	Shared decks and active user base	Plan to enable deck sharing and community content*
Tagging System	Flexible tagging helps organise decks	Implement simple but powerful tagging and filtering*
Add-ons Ecosystem	Enables powerful third-party extensions	Offer API/plugins to extend app functionality*
Keyboard Shortcuts	Efficient navigation and study flow	Design intuitive shortcuts for faster use*
Statistics Tracking	Basic review stats help monitor progress	Provide enhanced, interactive analytics dashboards*
Support for Multiple Card Types	Basic, cloze deletion, reversed cards	Support popular card types and AI-generated question variations*
Syncing via AnkiWeb	Seamless cross-device sync	Use secure cloud syncing for real-time updates*
Mobile Review Experience	Optimised for small screens	Design minimalistic and effective mobile UI*
Scheduling Flexibility	Adjust intervals manually	Allow users to tweak schedules as needed*
Backup and Export Options	Easy data export for backup	Provide simple backup and export/import features*
Support for LaTeX	Good for math/CS notation	Support LaTeX rendering for technical content*
Tag Hierarchies	Organise decks and cards in nested tags	Plan hierarchical tagging system for better organisation*
Multi-Language Support	Supports cards in any language	Support multilingual flashcards and interface*

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Table 1 – continued from previous page

Feature	Why I Like It in Anki	How AI Flashcards App Will Use/Improve It
Offline Access	Study without internet connection	Full offline functionality with sync on reconnect*

* Planned features are subject to development changes.

Table 2: Anki Features to Improve and AI Flashcards App Improvement Plans

Feature to Improve	Issue with Anki	Improvement Plan
Steep Learning Curve	Complex UI and manual setup can overwhelm beginners	Simple UI with onboarding tutorials and minimal setup*
Manual Card Creation	Time-consuming and error-prone	Automate flashcard creation using NLP and AI*
Complex Deck Organisation	Nested decks may confuse new users	Start with simple tagging, add hierarchy later*
Lack of Integrated Audio Revision	No built-in audio summaries	Include AI-generated podcasts and TTS*
Limited Built-in Analytics	Requires add-ons for detailed stats	Integrated progress dashboards with insights*
Inconsistent Cross-device Sync	Sync sometimes unreliable	Use cloud backend for real-time sync*
No Built-in Study Guidance	Relies on user self-management	Adaptive spaced repetition driven by confidence*
Overwhelming Customisability	Too many options can confuse users	Sensible defaults with optional advanced settings*

* Planned features are subject to development changes.

Justification:

While Anki's core features like its spaced repetition algorithm and customisability are industry standards, its complexity and reliance on manual inputs deter many learners. The AI Flashcards App will automate card creation, simplify user experience, and enhance engagement with AI-driven audio and analytics, making effective revision more accessible to a broader audience.

1.4.2 Quizlet

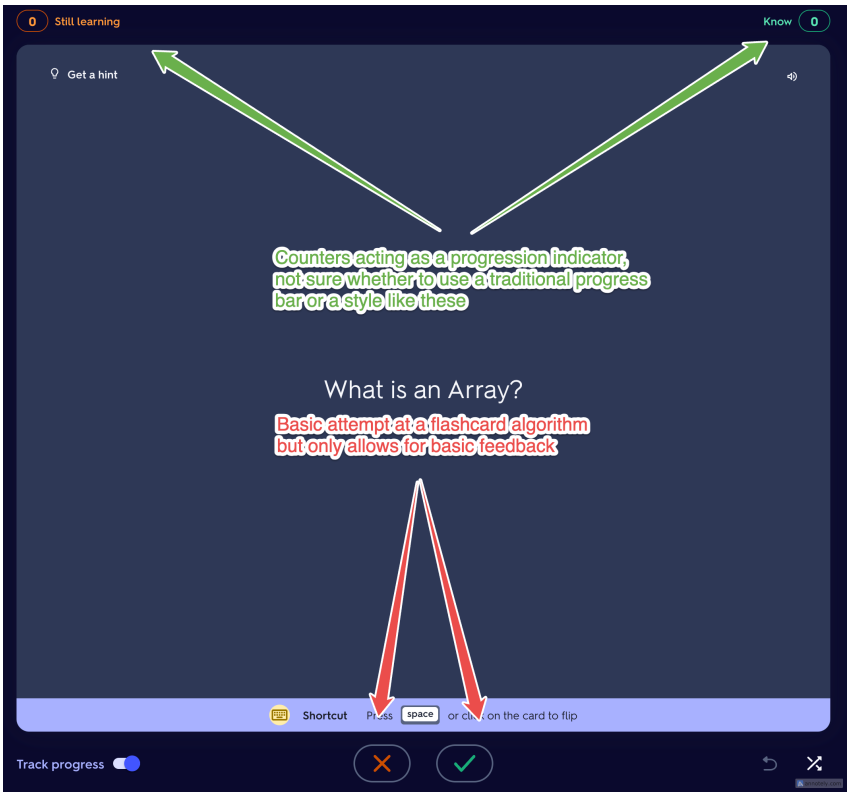

Figure 3: Quizlet Flashcard Revision Menu with Feedback Buttons

Quizlet is one of the most widely used flashcard platforms globally, especially popular among school and college students for its simple, user-friendly interface and diverse study modes. Unlike Anki, Quizlet places more emphasis on accessibility and ease of use rather than advanced algorithmic learning techniques. It offers a variety of study activities including flashcards, matching games, multiple-choice tests, and practice quizzes, aiming to engage users through interactive and varied revision styles.

Quizlet's strength lies in its vast community-driven database of shared flashcard sets across countless subjects, allowing users to quickly find ready-made study materials. Its web-based platform and mobile apps (iOS and Android) provide seamless syncing, enabling students to study anytime and anywhere. The platform's clean design and gamified features appeal especially to younger learners who prefer straightforward, visually engaging revision tools.

While Quizlet lacks a formal spaced repetition algorithm, it does provide basic feedback during study sessions, such as marking items "I know" or "I don't know," which introduces a minimal level of adaptive learning. It also supports multimedia integration including images and audio, making it useful for language learning and other subjects requiring auditory or visual memory aids.

Quizlet operates on a freemium model, offering a free tier with ads and limited features alongside a paid subscription that unlocks additional study modes, offline access, and ad-free use. This model has made Quizlet accessible to millions, but also a target for users who prefer

fully free, ad-free educational tools.

Table 3: Quizlet Current Features

Feature	**Description**	
Collaboration	Limited collaboration features, mostly public deck sharing	Real-time collaborative deck editing with version control and commenting*
AI-Powered Content Generation	No AI-generated content	Automated generation of flashcards, quizzes, and explanations from notes and textbooks*
Personalised Study Plans	No personalised study scheduling	Dynamic study plans tailored to individual goals, deadlines, and learning pace*
Cross-Device Syncing	Basic sync with some delays	Instant cross-device syncing with conflict resolution and offline support*
Accessibility	Basic accessibility options	Enhanced accessibility features including text-to-speech, dyslexia-friendly fonts, and keyboard navigation*
Multimedia Support	Supports images and audio	Expanded multimedia support with video embedding and interactive elements*
Integration	Minimal third-party integration	Integrates with calendars, note apps, and learning management systems (LMS)*
Community Engagement	Basic public decks	Community-driven challenges, leaderboards, and peer feedback systems*
Security	Standard user data protection	End-to-end encryption for user data and private decks*
Custom Feedback	Limited feedback options	AI-driven personalised feedback and hints during study sessions*

* Planned features are subject to development changes.

Table 4: Quizlet Features to Improve and Proposed Enhancements

Feature	**Current Quizlet**	**Improvement in AI Flashcards App**
Adaptive Learning	No formal spaced repetition or algorithm; feedback is limited to "know" or "don't know"	Implements advanced adaptive spaced repetition algorithm adjusting intervals based on user confidence and performance*
Customisation	Limited card formatting and customization options	Full support for rich text, images, audio, and AI-generated questions*
Pricing Model	Freemium with ads and paid tiers	Fully free with no ads or paywalls, ensuring open access for all users
Analytics	Basic study statistics, no deep progress tracking	Built-in detailed analytics showing learning progress and weaknesses*
Offline Mode	Only with paid subscription	Free offline support planned to maximise accessibility*
Algorithm Transparency	Limited information about underlying learning algorithms	Open and user-transparent adaptive algorithms designed around cognitive science*
Sharing	Public deck sharing but limited collaboration	Plans for seamless collaborative deck creation and sharing*
Content Creation	Mostly manual input by users	Automated note-to-flashcard conversion using AI and NLP*
Mobile Functionality	Good but feature-limited in free version	Full feature parity planned across platforms with mobile optimisation*
Motivation Features	Basic gamification and feedback	Advanced motivational feedback and AI-driven encouragement planned*

* Planned features are subject to development changes.

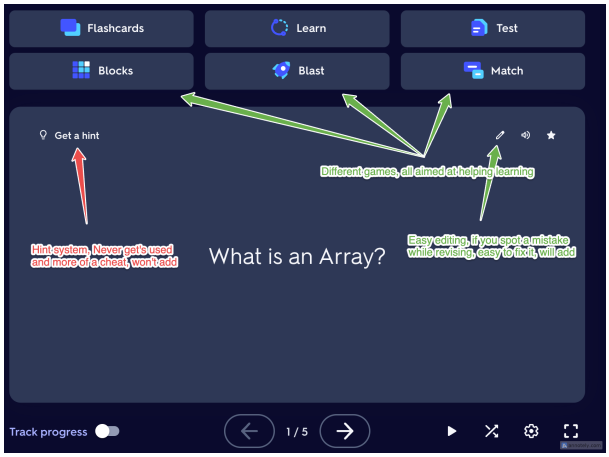

Figure 4: Quizlet Flashcard UI

1.4.3 Brainscape

Brainscape is an adaptive flashcard app designed to optimise learning through a scientifically backed spaced repetition system. Unlike some other platforms, Brainscape emphasises efficient memorisation by dynamically adjusting the timing of flashcard reviews based on the learner's confidence ratings.
The platform allows users to create their own flashcards or access a vast library of shared content across numerous subjects. Its clean, minimalistic interface is tailored to reduce cognitive load and keep users focused on retention. Brainscape is available on both web and mobile devices, offering seamless syncing to enable study anytime, anywhere.

A key feature of Brainscape is its adaptive algorithm which personalises the repetition intervals, making sure that learners review material right before they are likely to forget it. This approach aims to maximise retention while minimising study time, making it particularly popular among students preparing for exams and professionals looking for efficient upskilling.

Brainscape operates on a freemium model with a free tier that includes core functionalities, and a premium subscription that unlocks enhanced features such as detailed analytics, expert-created flashcard decks, and offline access. Its focus on cognitive science principles and simplicity has earned it a dedicated user base seeking effective and straightforward study tools.

Table 5: Brainscape Current Features and Usage in AI Flashcards App

Feature	Description	How It's Used / Justification
Adaptive Spaced Repetition	Dynamically adjusts flashcard review intervals based on user-rated confidence levels.	Core learning logic used to prioritise difficult material and minimise overexposure to mastered content.
User-Generated Content	Users can create and edit their own flashcards and decks manually.	Encourages learner autonomy and allows tailoring of material to individual goals or curricula.
Pre-Made Deck Library	Extensive database of subject-specific flashcard sets available to all users.	Helps users get started quickly or supplement their own decks with expert-vetted material.
Cross-Platform Syncing	Flashcards are synced across devices in real time (web and mobile).	Promotes flexibility and consistency in study routines across different settings.
Minimalist Interface	Clean and distraction-free UI designed for efficiency and focus.	Reduces cognitive load, helping students concentrate on material instead of UI clutter.
Confidence-Based Rating	Users rate their understanding after each flashcard from 1 (low) to 5 (high).	Drives the adaptive algorithm, ensuring the system targets weak areas more frequently.
Premium Subscription	Unlocks extra features including offline access, advanced stats, and expert content.	Monetises the platform but restricts access to helpful features without payment.
Basic Analytics	Tracks study time, confidence history, and subject progress in a simplified dashboard.	Offers limited insight to support performance tracking, but lacks diagnostic depth.
Deck Organisation	Users can group related flashcards into folders and subfolders.	Improves content navigation and management for complex subjects or courses.
Simple Gamification	Offers badges and streak tracking to promote consistent study habits.	Provides light motivational incentives without being overly game-like.
Limited Collaboration	No multi-user deck editing or shared learning sessions.	Restricts cooperative learning, which could be addressed in a future app version.
Text-Only Focus	Lacks support for audio, images, or rich formatting.	Limits effectiveness for visual or auditory learners; an area for clear enhancement.

* Planned features are subject to development changes.

Table 6: Proposed Improvements Over Brainscape Features in AI Flashcards App

Feature	**Current Brainscape**	**Improvement in AI Flashcards App**
Adaptive Spaced Repetition	Dynamic review based on confidence ratings	Incorporates AI to adjust intervals considering cognitive load, forgetting curves, and user behaviour for maximised retention*
User-Generated Content	User-created decks	AI-assisted deck creation from notes and textbooks, reducing manual effort*
Pre-Made Deck Library	Large collection of expert and community decks	Crowdsourced and AI-curated decks with quality ratings and personalised recommendations*
Cross-Platform Syncing	Web, iOS, and Android syncing	Real-time syncing with conflict resolution and offline editing support*
Clean Interface	Minimalist, distraction-free	Customisable UI themes and layouts tailored to user preferences*
Confidence-Based Rating	User self-rates knowledge	AI-estimated confidence using interaction data plus user input for improved scheduling*
Premium Subscription	Paid unlocks for analytics and offline	Fully free core features with optional privacy-respecting donations and unlocked analytics*

* Planned features are subject to development changes.

Figure 5: Brainscape Home Screen

1.5 The SM-2 Algorithm and Mathematical Scheduling

A fundamental feature of Anki, and the one most directly influencing my own solution, is it's use of the SM-2 spaced repetition algorithm. This algorithm was developed by Piotr Wozniak in 1985 for SuperMemo and is designed to determine optimal review intervals using user feedback on recall difficulty. Spaced repetition, when grounded in algorithms like SM2, improves memory retention through the spacing effect, a psychological phenomenon that shows information is better remembered when exposures are spaced over time.

The core idea is to calculate a new interval I_n after each review, based on the user's performance, using a formula influenced by both previous interval and an ease factor. SM2 adjusts this ease factor (EF) based on how well the user remembers the item.

The general logic follows these rules:

- If the user grades their recall quality less than 3 (on a scale from 0 to 5), the item is scheduled to be reviewed again soon — usually the next day.
- If the grade is 3 or above, a new interval is calculated:

$$\begin{aligned} I_1 &= 1 \\ I_2 &= 6 \\ I_n &= I_{n-1} \cdot EF \quad \text{for } n > 2 \end{aligned}$$

- The ease factor is updated as follows:

$$EF' = EF - 0.8 + (0.28 \cdot q) - (0.02 \cdot q^2)$$

  where q is the quality of the response (0–5), and EF is constrained to a minimum of 1.3.

The exponential nature of the interval calculation allows well-remembered items to be reviewed far less frequently over time, conserving cognitive effort for more difficult items. For instance, if a card is repeatedly recalled successfully with a consistent EF of 2.5, the intervals will expand rapidly: 1 day, 6 days, 15 days, 37 days, 92 days, and so on. This aligns with human forgetting curves, where memory retention drops off sharply at first, but then levels off.

From a computational standpoint, this algorithm is a perfect example of a lightweight yet effective method for intelligent scheduling. It uses basic arithmetic and quadratic expressions to adapt to the user's performance without requiring complex machine learning techniques, making it highly suitable for low-power or offline devices like a smartphone.

I intend to implement a simplified or modified version of the SM-2 algorithm in my project. The scheduling function will track user performance on each flashcard and update review intervals using a similar exponential model. This will allow my app to tailor repetition to individual users in a mathematically sound way.

This feature is crucial to the effectiveness of spaced repetition tools and is a key component I will adopt and adapt for my own app.[1]

[1] SM-2 was first introduced by Piotr Wozniak as part of the SuperMemo project. See a detailed breakdown here: RemNote SM-2 Guide.

1.6 Essential Features of the Proposed Solution

Table 7: Essential Features of the Proposed Solution

Feature	**Justification**	**How It Will Be Used**
Automated Flashcard Generation	Reduces manual work and speeds up revision preparation, making it more accessible and less time-consuming	Notes (PDF or text) will be scanned and converted into flashcards using NLP to extract key points, definitions, and questions
Spaced Repetition Algorithm	Supports efficient memorisation by using proven cognitive science techniques	Flashcard intervals will adapt based on user confidence and performance, enhancing long-term retention
Custom Deck Management	Allows personalisation and structured revision	Users can create and categorise decks by subject, topic, or difficulty level; changes sync across sessions
AI Feedback and Motivation	Keeps users engaged and encourages continued use of the app	System provides encouragement, reminders, and tailored progress feedback after each study session
Multi-Modal Learning Support	Supports a wider range of learning styles and increases accessibility	Flashcards can be read aloud using text-to-speech or summarised in short AI-generated podcasts
Cross-Platform Accessibility	Ensures usability across different environments and devices	Both desktop and mobile versions will offer the same core features and sync data between platforms
Simple, Intuitive UI/UX	Prevents cognitive overload and supports a better user experience	Interface designed with clean visuals, minimal distractions, and easy navigation for students
Data-Driven Progress Analytics	Helps users identify weak areas and track improvements over time	Provides visual feedback on accuracy, study time, and topics requiring further revision

* Feature implementation may vary slightly depending on development constraints.

1.7 Limitations of the Proposed Solution

Despite its innovative and educationally valuable features, Delphi has a number of limitations that reflect both practical development constraints and technical boundaries:

- **Natural Language Processing (NLP) Reliability:** While NLP techniques enable automatic flashcard generation from user notes, these models can struggle with handwritten input, poorly structured text, or domain-specific terminology. Misinterpretations may result in irrelevant or inaccurate questions. Furthermore, without advanced fine-tuning, the generated content may lack pedagogical depth or consistency with user expectations.
- **Generalised AI Models Without User Personalisation:** The AI used for flashcard and quiz generation is based on general-purpose large language models (LLMs) and lacks deep user personalisation. It does not adapt to individual user performance over time, learning style preferences, or cognitive strengths/weaknesses. Fully adaptive AI would require complex reinforcement learning pipelines and continuous user data collection, which are outside the scope of this project.
- **AI Feedback May Lack Pedagogical Rigor:** Although the system aims to offer automated encouragement and performance feedback, AI-generated feedback may sometimes be vague, overly generic, or misleading. Without expert-curated intervention, this could negatively impact user confidence or learning outcomes in some cases.
- **Computational Constraints and Offline Limitations:** While AI features such as flashcard generation, summarisation, and feedback significantly enhance the app's learning potential, they introduce considerable computational demands. Running these models locally—especially on mobile devices—is largely impractical due to limited processing power, memory, and battery capacity. As a result, during development, AI inference may need to be offloaded to a more powerful personal computer or external server. This introduces dependency on internet connectivity and backend infrastructure, reducing offline availability. Furthermore, compressing models for on-device deployment can reduce their accuracy and effectiveness. Full offline parity would require bundling large language models into the app, significantly increasing its size, reducing device compatibility, and introducing additional privacy and update challenges.
- **Lack of Secure User Accounts:** The current version of the solution does not include user account management, login, or profile-based data storage. This limits long-term tracking of user progress, cross-device syncing, and personalised content retrieval. While it reduces complexity and protects user anonymity, it also restricts the app's potential for growth and community features.
- **Device and Platform Limitations:** The app is designed primarily for iOS using Swift, and does not currently support Android or web platforms. Additionally, older devices may struggle with rendering or processing-intensive tasks such as text-to-speech or AI-generated flashcards.
- **Limited Gamification and Motivation Systems:** Although motivational AI feedback is planned, more advanced features like leaderboards, community challenges, or reward systems are not included in this release. This could reduce long-term user engagement compared to platforms with stronger gamified ecosystems.