University of Plymouth

School of Engineering, Computing, and Mathematics

Comp 3000 Final Stage Computing Project 2024/2025
Leitner Language Learning – Language Learning Application

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Acknowledgements

I would like to thank my project supervisor Vivek Singh for the help that they have provided throughout the project, I would also like to thank my girlfriend and my family for their support.

Abstract

GitHub Page: https://github.com/Zedster82/Comp-3000-Owen-Maynard

Report Video:

This report describes a software project, documenting the development process of an application intended to help users learn topics that they can choose, focused upon language learning.

The functional requirements of this application are outlined and are followed by a look into the overall design and architecture of the system, as well as the chosen technologies and method of approach.

The development process is discussed, presenting an overview of the challenges faces during the development process. It also covers the development changes that happened over time, as some of the requirements of the project had to be changed over time.

Thorough testing was carried out, and this is also covered, showing the methods that I used.

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1. Introduction

While there are many services and tools available to help with learning a language. The current available solutions fail to implement good categories and sectioning of topics within a language.

The system presented in this report, aims to provide a well implemented solution of the Leitner System.

2. Background

What is the Leitner System?

The Leitner system is a widely used method for improving the efficiency of learning with flashcards, based on the principle of spaced repetition. In this system, flashcards are sorted into groups according to how well the learner knows each one; cards answered correctly are moved to groups reviewed less frequently, while those answered incorrectly are reviewed more often. This approach helps learners focus on material they find challenging, optimizing memory retention over time (Leitner, 1972).

2.1 Competition

Applications for learning languages is not a new concept and there are already multiple applications that aim to help in this area, there is lots of competition that cover a range of use cases. Two examples of competitors are as follows:

- Duolingo
    - Duolingo is an application that allows the user to select a language that they want to learn. As of 2022 it has over 500 million downloads (Duolingo Reports) and is the most popular application in the Education category.
- Babbel
    - Babbel is a subscription-based language learning software. They have over 1000 employees (Wikipedia – Babbel). Babbel has its own research backed method of language learning.

2.2 Limitations of competitors

These applications do have limits, these limitations are the areas that I intend to focus upon, filling the gap in the market made available.

Firstly, these applications do not many options of categories. Duolingo has “chapters” that allow users to progress through a set learning plan. While this approach suits most learners, this does not allow user to control their own learning.

2.3 Objectives

The aim of this project is to create an application that will help users, to learn and improve their language skills via flashcards and the Leitner system. The objectives that have been set out are:

- To implement improved learning techniques through spaced repetition
- To build an application that allows users to create their own flashcards and practice them.
- To design a user interface in way that is clear in functionality and design.
- Allows the user to store the information that they want on a server and be able to retrieve that information when required.
- To follow agile project management techniques and build the application within the time allocated.

3. Legal Social and Ethical

3.1 Legal

3.1.1 GDPR (General Data Protection Regulation)

GDPR are the guidelines which are included in the EU law, they cover things such as how users' information should be stored and handled to ensure that misuse of it does not happen. It applies to any application that stores users' information. It is made up of 7 key principles (Information Commissioner's Office).

GDPR Principles Implementation

The Leitner Language Learning application addresses the seven GDPR principles in its design and implementation. For lawfulness, fairness, and transparency, the application shows explicit user consent mechanisms before collecting playlist and flashcard data, clearly communicating how user data is stored and processed. Regarding **purpose limitation**, the application collects data solely for providing language learning functionality, with API endpoints specifically designed for retrieving and managing playlists without repurposing data for marketing or analytics. The application demonstrates **data minimization** by collecting only essential information needed for functionality (playlist titles and flashcard content), avoiding unnecessary personal details.

For **accuracy**, the application allows users to create and manage their learning content, though additional validation and correction mechanisms could strengthen this principle. When an account is deleted, all the user data that is connected to that account will be deleted, making sure that data is not stored for longer than required. The current implementation is running on localhost and using http, however when this is deployed onto a server it will use https and therefore be encrypted. Session and authentication tokens are also used to ensure that users cannot perform action without permission.

Accountability would be achieved by documenting all data processing activities and maintaining records of consent.

Data Protection Officer Considerations

A DPO is not required for this small-scale application as it doesn't systematically monitor individuals or process special data categories at scale. However, if the application expands to serve many users across regions or begins handling sensitive data (like biometric information), a DPO would be necessary to ensure compliance, conduct assessments, and act as the contact point for data subjects and authorities.

3.1.2 Licencing

While developing a software project it is imperative that you have the licence to use the packages and other software that you are using in the project. Most of the 3rd party sources that I have used are either licenses to be used for any project, either commercial or for studies. Some of them may require credit. The credits for packages and software that I have used can be seen in the appendix of this report.

3.2 Social and Ethical

The application raises several important social and ethical concerns. As a language learning tool, it must ensure cultural sensitivity in user-generated flashcard content to avoid stereotypes or misrepresentations. Accessibility issues could arise if the interface doesn't accommodate users with different abilities, such as inadequate color contrast for the visually impaired or difficult-to-activate touch targets. Additionally, the digital divide means this educational technology may primarily benefit those with regular access to digital devices, potentially excluding disadvantaged learners who might most benefit from language acquisition tools.

4.1 Requirements

The requirements for the project are the most important, they outline exactly what is required within the project.

There are 3 sections to the requirements, core requirements, which are required to make the MVP (Minimal Viable Product), the Desired requirements – these are requirements that would make the user experience better, such as quality of life features like a search bar.

Finally, there are optional requirements. These consist of design features that do not contribute considerably to the user's experience. Implementing a few of these would make the overall experience of the software better for the user.

4.1 Functional Requirements

4.1.1 Core Requirements (MVP)

The core requirements for this application are as follows –

- User authentication and account management

    - A user should be able to log in and out of their account
- Create, view, edit and delete flashcards and playlists
- Add, edit and remove individual flashcards within playlists
- Organize flashcards using the Leitner system methodology
- Multi-language support for content creation
- Spaced repetition scheduling based on user performance

Desirable requirements –

- Progress tracking across learning sessions
- Search functionality to find specific flashcards or playlists
- Import/export flashcard data
- Multi-language support for content creation (Tagging Flashcards)
- Statistical reporting on learning progress
- Detailed Error handling and user feedback

4.2 Non-Functional Requirements

The non-functional requirements for this application are as follows -

- Offline functionality with synchronization when online
- Scalability to support increasing user base and content volume

5. Implementation of Chosen Technologies

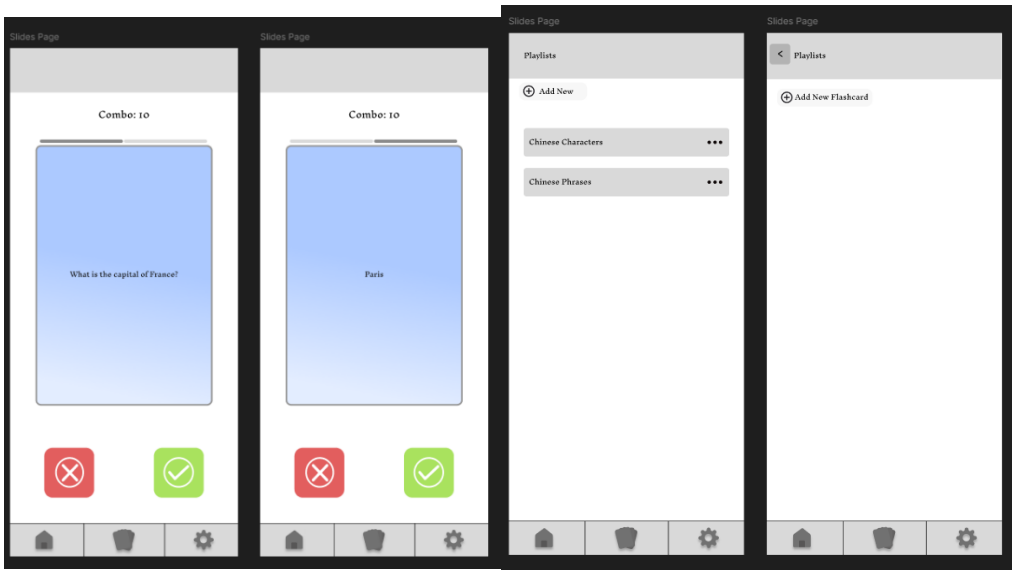
At the start of the project, a high-level plan of the structure was created. This breaks the development of the project down into 5 different phases:

1. Frontend Design
2. Backend Design and Development
3. Frontend Development
4. Frontend and Backend Integration
5. Project Analysis and Report

5.1 Front End application

5.1.1 Design

For the design of the front-end application I used Figma, these designs are made to outline the key features that will be required. Designs made:



These are the designs for the Main flashcard page, the playlists and Editing playlist page.

The hot bar design is used to allow the user quick and easy navigation of the application to the most important pages. This allows the user to get to them fast without having to navigate through a complicated route.

5.1.2 Feedback

Using the designs that I made I gathered some feedback from peers to improve the UI design.

- The application lacks visual confirmation when actions are completed successfully
- Missing feedback on state of learning (Users don’t know how many they got correct or wrong)
- No toast messages appear after saving or deleting content
- Loading states aren't clearly indicated when fetching data from the server
- Error messages are too generic and don't provide actionable solutions
- The Leitner system progression isn't visualized clearly for users
- Form validation errors only appear after submission rather than in real-time

- No confirmation dialogs for destructive actions like deleting playlists
- Empty states don't guide users on how to get started

The feedback that I gathered clearly showed that users did not have much feedback for things such as how many they got correct. They expressed that there was not enough information being shown to the user.

They also expressed that there is not enough feedback when trying to perform actions that will manipulate data.

These are some of the areas that I kept in mind during the development to ensure that this was improved upon.

5.1.3 Development

In the development stage, I created a React Native app.
The reason for this is that it will build into applications that can work for the Web, Android and IOS. This means that you only need one codebase to get your app to work in all these frameworks, improving development efficiency and consistency between platforms.

Cost – React Native is free and has many free compatible libraries developed for it.

Market Reach – Catering to multiple markets allows the application to reach a wider range of potential users.

Modern Technology – React Native is relatively new in the environment of app development and as such is still being constantly updated and maintained. This ensures that my application will be modern and up to date even when encountering new phones and software updates.

The language that this is in is JavaScript, however I also use TypeScript for the majority of the files. The main reason for this is so that I can use the type safe features of TS. This allows me to create Types and Components that explicitly state the type that they require and will return. Reused variables such as a Playlist have global Types, allowing the data in them to be consistent throughout the project.

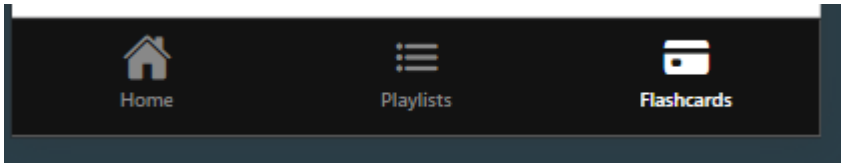
```
export type PlaylistType = {
  _id: string;
  title: string;
  user: string;
  cardList?: string[]; // or any other type that describes the card list
}
```

Here is a Type for the Playlist, giving it defined properties and types.

The editor that I used was VS Code, allowing me to develop efficiently with all the tools that I need.

I have used expo router as the file path manager, this allows me to easily implement features that require user to navigate through the file structure.

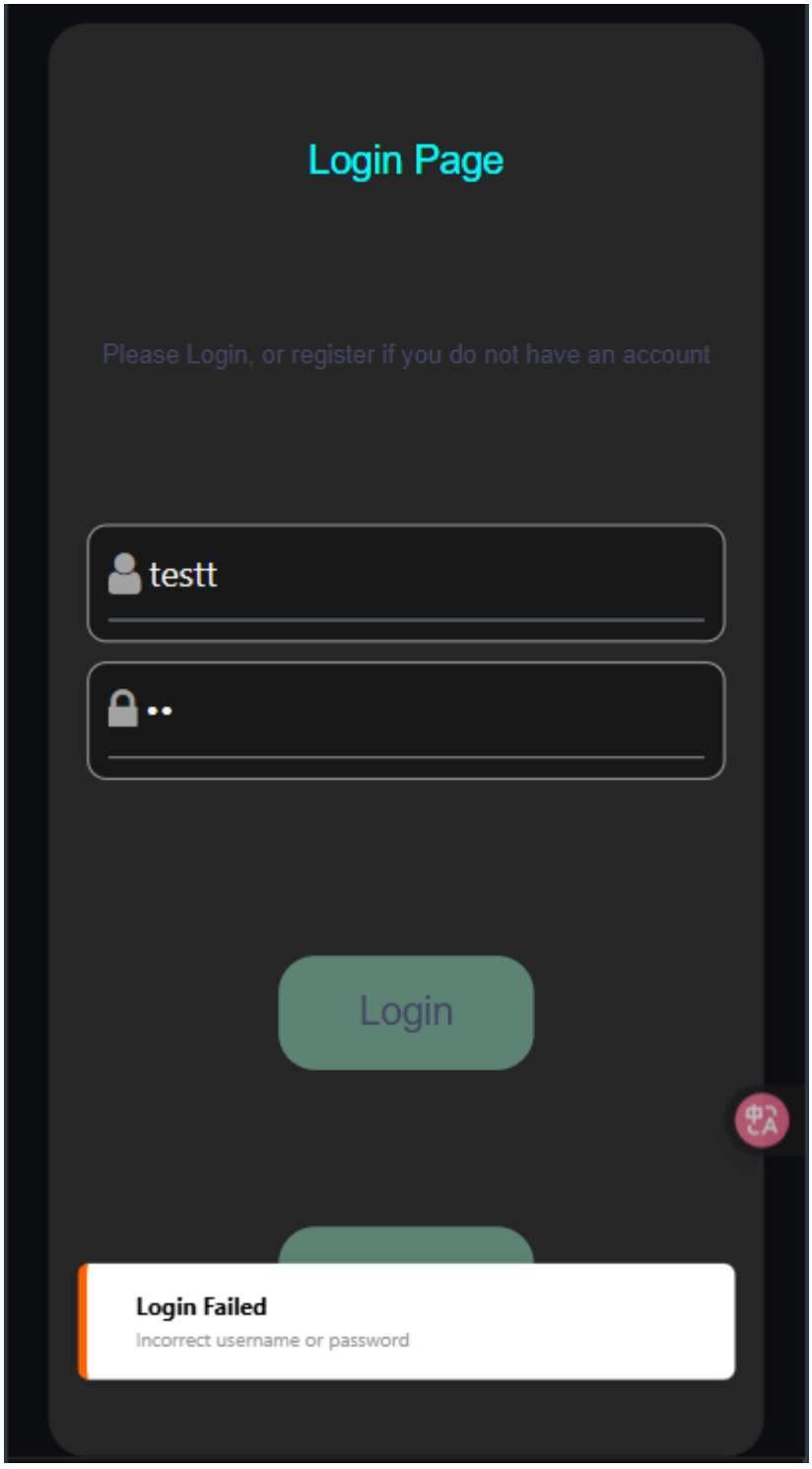
A good example of this is the hot bar.



This hot bar navigation I made using the expo router <Tabs> Component. From this I can define what Pages I want to display in the tabs.

For navigating between pages, the user will interact with a button, the button will then push the new page to the router stack, changing the page.

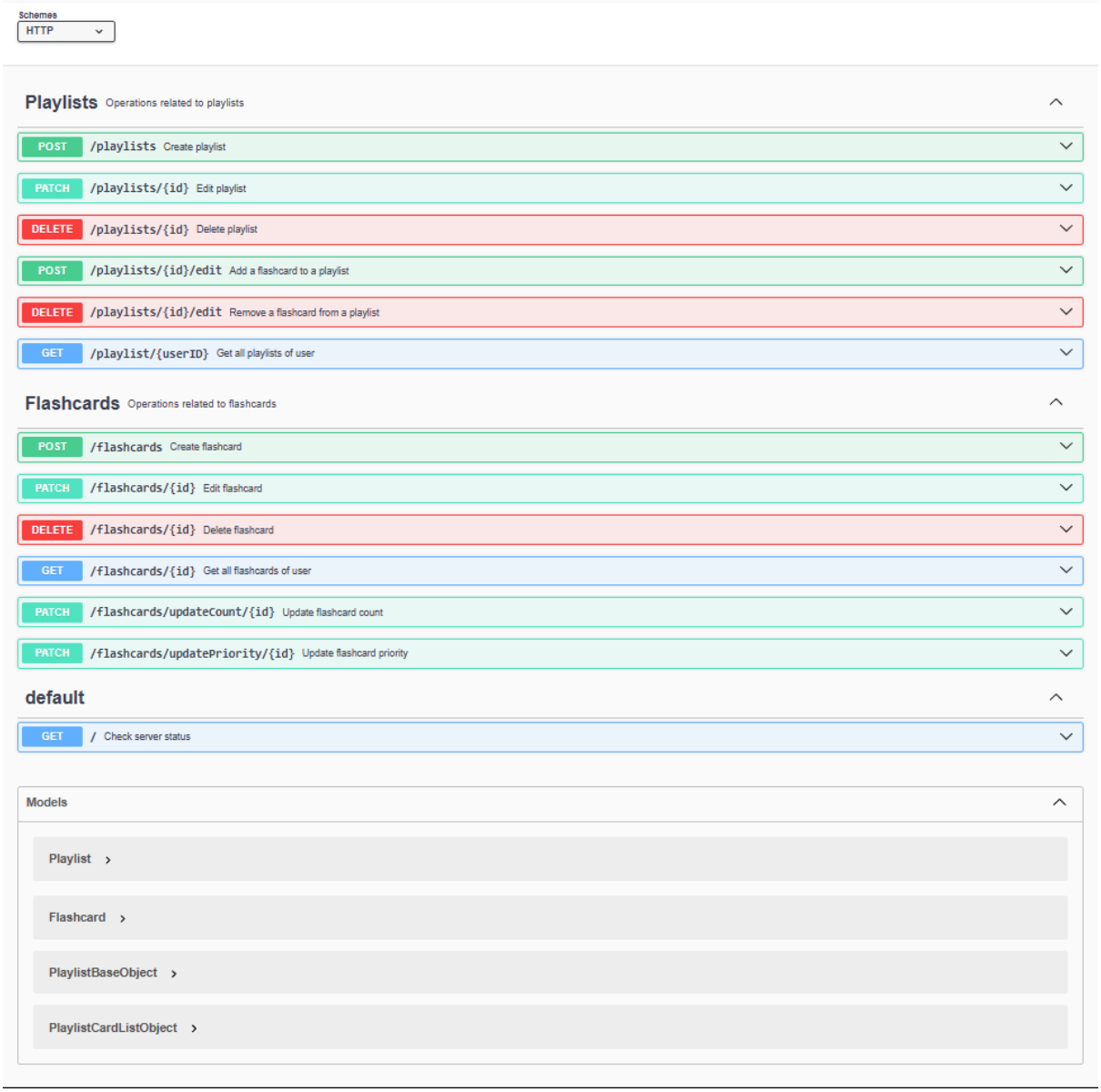
There are clear error messages throughout the application, an example of a failed login toast message:



5.2 Server and Database

5.2.1 Design and Swagger Page

For the design of the backend, I created a swagger page that would outline ever route that I would use. This helps to make sure that I do not miss something. It also helps during the development process allowing me to reference it while I am making the routes, making sure that the code I am writing matches the intended process.



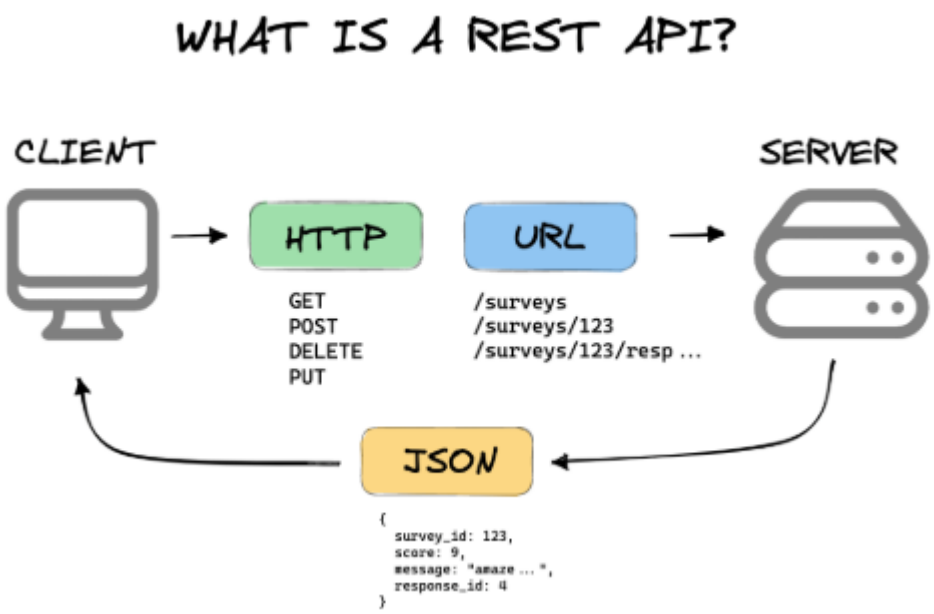
5.2.2 Development

The server is built on express and is run using node.

The reason that I chose Express is because its lightweight and minimalist design allows for rapid API development while providing the flexibility needed for a learning application with evolving requirements.

I also have familiarity with it in past projects allowing me to get developing quickly.

The API is formatted so that it adheres to the RESTful API standard, where the server only accepts GET, POST, PUT, POST, DELETE requests to maintain the data in the database. Only CRUD functions are allowed (Create, Read, Update and Delete). This means that the server and client communicate in a standardised manner.



I implemented a range of node packages within the server as well such a bcrypt and jsonwebtoken.

Cross Origin Resource Sharing is used to make sure that front end applications such as a Browser can access the website, as they require CORS to be enabled as a security feature.

The database built with MongoDB and Is running locally on the same machine as the server. When scaling, the environment variable for the database location would be replaces with the server URL.

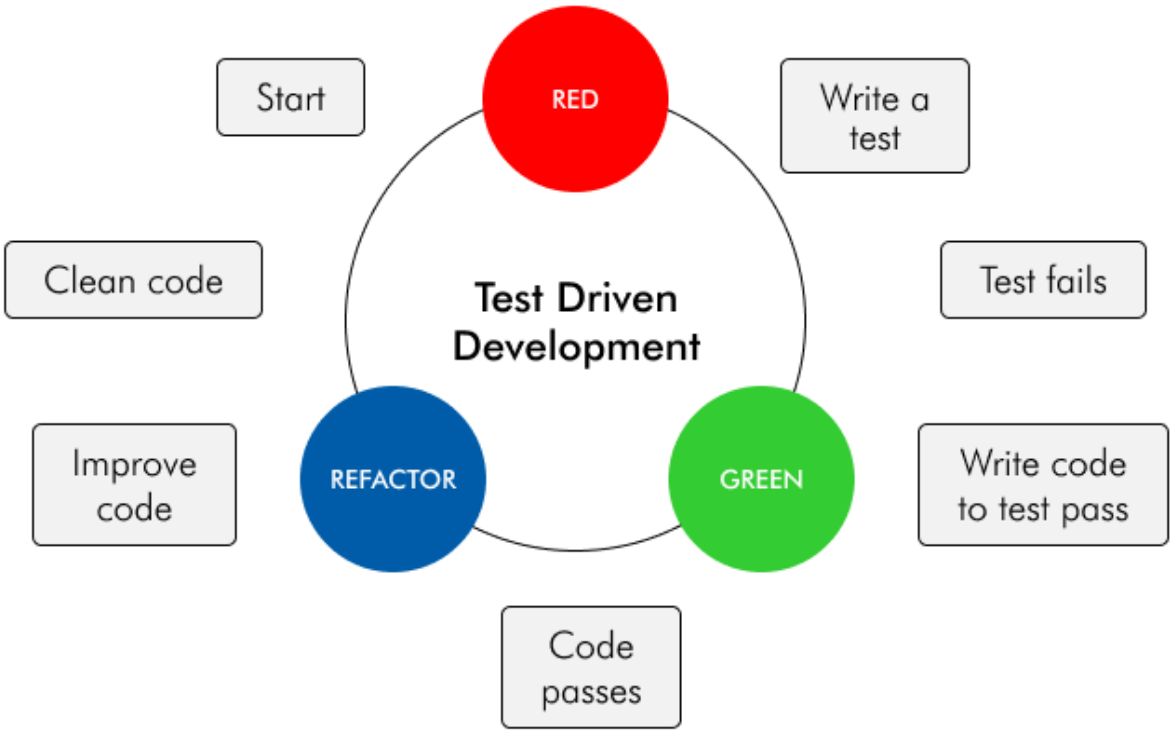
During the development, I encountered an issue with a node package that I was using – react native gesture handler. A gesture handler is a component that allows the user to drag a component around the screen as if they were grabbing it.

The issue was that

5.2.3 Testing

Unit and integration testing represent different scopes in the testing pyramid, where unit tests verify individual components in isolation while integration tests examine how these components work together, ensuring proper communication between modules as described by Martin Fowler in his seminal work on continuous integration (Fowler, 2006).

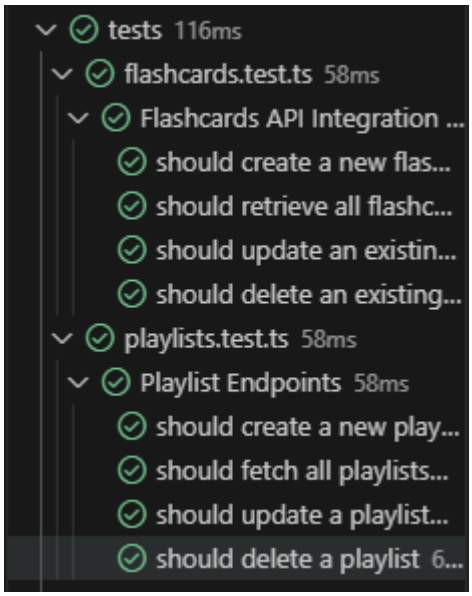
For the testing of the backend, I created integration and unit tests for the routes. The reason for this is so that I could perform test driven development. TDD is an approach where the testing is partially or fully written, then writing the functional code to get the tests to pass and then refactoring or looping through the process again.



This approach provides a few benefits, one of which is that it means the functionality is designed before the implementation, helping to maintain clarity on what the functions of a code section may be. It also ensures that new code added to the system will still work, as you can verify that the functionality has not been changed in a destructive manner.

These test help to make sure that the code that I have written is of standard and performs consistently, helping to reduce bugs and errors. To write the tests I used Vitest, which is a modern testing package.

I created tests for each area of my project

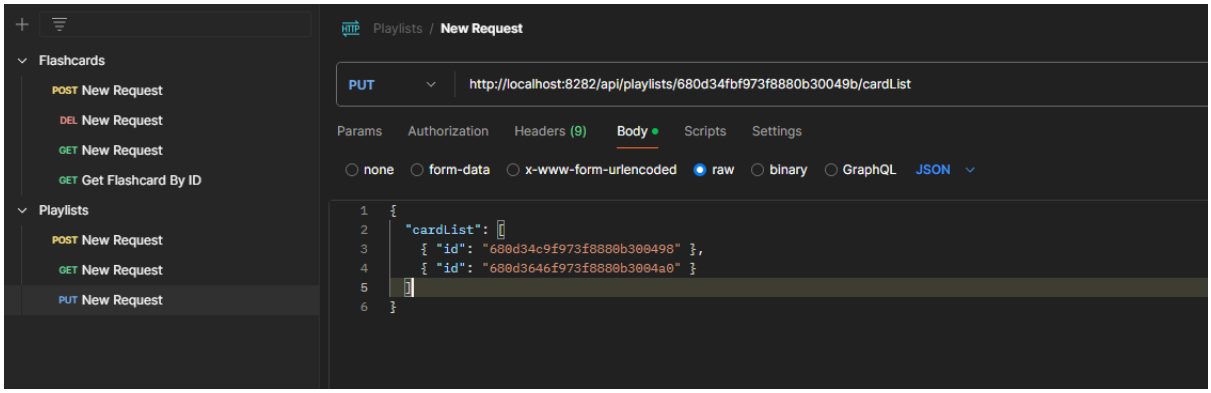


This is a specific test for getting the flashcards from the database:

```
// Test getting all flashcards
it('should retrieve all flashcards', async () => {
  try {
    const response = await axios.get(`${BASE_URL}/api/flashcards/${testFlashcard.userID}`);
    console.log("Get Flashcards, Flashcard ID: ", flashcardID)
    console.log("Get Flashcards, Body Flashcard ID: ", response.data.flashcards[0]._id)
    console.log("Get Flashcards Response: ", response.data)
    expect(response.status).toBe(200);
    expect(Array.isArray(response.data.flashcards)).toBe(true);
    expect(response.data.flashcards[0]._id).toBe(flashcardID);

    // flashcardID = response.data.flashcards[0]._id; // Assuming the first flashcard is the one we just created
    // Check if our created flashcard is in the list
    // expect(response.data.flashcard).contains(testFlashcard)
  } catch (error: any) {
    console.error('Error retrieving flashcards:', error.response?.data || error.message);
    throw error;
  }
});
```

I also conducted manual testing throughout the project, using postman to test out responses:



Continuous Integration and Continuous Deployment (CICD)

5.3 Frontend and Backend Integration

The integration process was not difficult as I have planned out the types of data and the routes that the frontend would use to interact with the server.

This phase required transferring the testing states used in the frontend into fully fleshed out requests to the server, managing the state of all the variables and data.

6. Method of Approach

6.1 Agile

I used the agile project management methodology during the design development and implementation of this project.

The agile methodology breaks the process into smaller chunks, where small incrementing parts of the project are contributed.

These small chunks are referred to as sprints, they usually consist of a 2-week period where you identify what tasks you will try to take on during the 2-week period, then at the end evaluating the success of the sprint and deciding some next steps for the next sprint.

The advantage of this method is that it allows you to restructure the process of what tasks you will need to complete. This means it is much more resilient to feature changes and will not derail the entire project if a small section does not go to plan.

This methodology fits perfectly with this project as the requirements may need to change, either to increase the scope or decrease if a feature is not possible or viable to implement.

For this project I used 2-week sprints, allowing changes to be made at regular intervals throughout the project life cycle.

7. Project Management

7.1 Trello

Trello is a tool that lets you organize ideas, concepts, to-dos, and anything else you like. (Trello, 2017)

To keep the track of the project and what I needed to do I used Trello, using user stories as the measurement for each requirement.

7.2 Version Control

For version control I used a github repository that I can commit to, this tracks

8. End Project Report

8.1 Objectives Review

Overall, the project was completed successfully, there were a few minor issues that I encountered along the way, however these were overcome and did not impact the final product. The project meets all the core requirements and meets some of the desirable requirements, meaning that it is successful in this manner.

Objectives Review:

The main objective of the project was to provide a well implemented solution of the Leitner System.

This objective has been successfully achieved, as I have developed an application that enables users to create and manage flashcards and playlists, with all data securely stored and retrieved from a backend server. The app fully implements the Leitner System by allowing users to review flashcards in a spaced repetition manner, track their progress, and focus on cards they find most challenging. The integration of a robust backend ensures that user data is persistent and accessible across sessions, while the frontend provides an intuitive interface for efficient learning. This comprehensive approach demonstrates that the core goal of delivering a functional Leitner System application has been met.

8.1 Changes during the project

During the project development, there were some minor changes to what the functionality of the frontend would be, however these changes do not impact the overall project, as they refer to how to user would interact with the application. Specifically the gesture handler was reused as a static handler to see if the user swiped the page.

9. Project Postmortem

9.1 Technologies Evaluation

The frontend of this project is built using React Native with Expo, leveraging the Expo Router for modern file-based navigation. React Native was chosen for its ability to deliver a performant, cross-platform mobile experience using a single codebase, which accelerates development and maintenance. Expo simplifies the setup and provides a rich ecosystem of libraries, making it easier to manage assets, handle device APIs, and deploy updates.

TypeScript is used throughout the codebase to provide static type checking, improving code reliability and developer productivity. The use of React Query and Axios for data fetching ensures efficient state management and seamless communication with the backend API. Additionally, libraries like React Native Reanimated and Gesture Handler are utilized to create smooth, interactive flashcard animations, enhancing the user experience.

I chose this technology stack for its balance of rapid development, strong community support, and the ability to deliver a polished, maintainable application across multiple platforms.

9.2 Developer Performance Evaluation

During development I aimed to work between 20-30 hours due to the number of sprints.

In most sprints this was met however some sprints required more attention and some required less, as the tasks chosen for the sprint were not as resource intensive.

9.3 Project Management Evaluation

For this project I chose Agile as the project management methodology to use. This worked well as I was able to split the work up into manageable chunks and keep reiterating. This is more useful than another methodology such as waterfall as there was times that I had to go back in steps between sprints. Another methodology such as kanban may have been better, however I think that Agile suits the project well and there is no reason to change the methodology.

9.4 The future

Currently the application is in a good state with most of the core features implemented.

However, in the future there are other features that are desirable that would be great to add.

Developing this further would be improved as the project is documented well, meaning that even if the developer has no familiarity with the project, they will be able to understand the codebase and develop new features effectively and quickly.

One feature that would be nice to implement is the tagging of cards so that they can fit a category, then being able to search that category. For example a user could tag a card as a French card, then when they are adding to a playlist they are using for French, they can easily search for the tag and add the card.

10. Conclusion

While my application does not create anything groundbreaking, it solves the gaps and problems that a lot of the competitors in the same subject fail to solve. It also is robust, during the design and development process, I focused heavily on testing, documentation and ensuring type safety. This means that the quality of the code that I have written is of near production standard, allowing anyone else to pick up the project and familiarise themselves with the codebase. If they are confused about what a function might do there are Interfaces, explicitly stating the types. If they want to see what the routes of the server are and what types of data it will respond with, it is documented in the swagger page.

The goal of the project was to create an implementation of the Leitner system for language learning. This project has achieved all the objectives that are core to the product. Meeting some desirable requirements.

Some setbacks were encountered, although I recovered quickly and got back on track.

In the future this application could be developed on further. A focus during development was explicit typing and documentation, therefore making this a feasible and easier task. This could also be published into the market and would not take much more development.

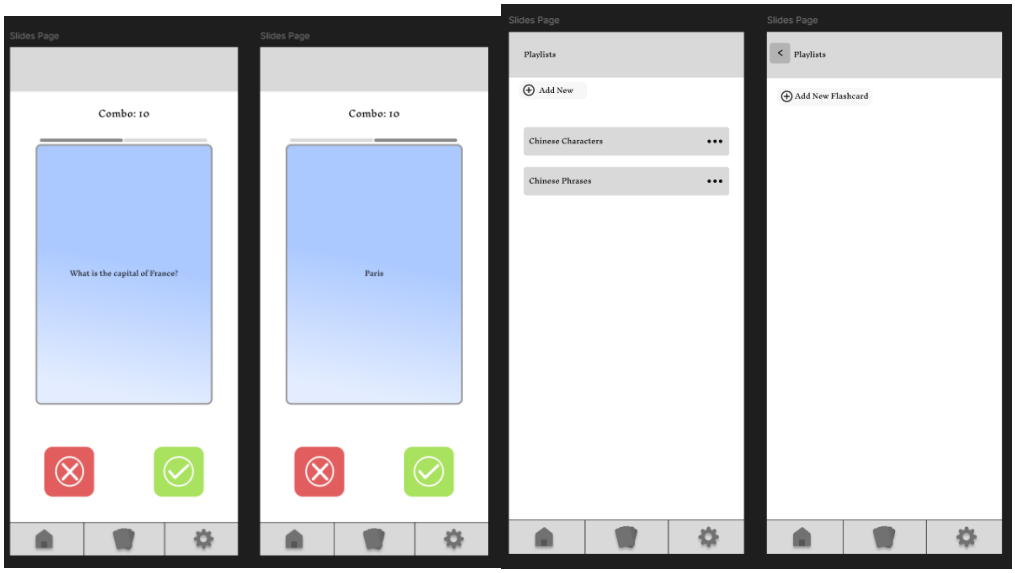
Sprints

Sprint 1- 13/12/2024- 27/12/2024

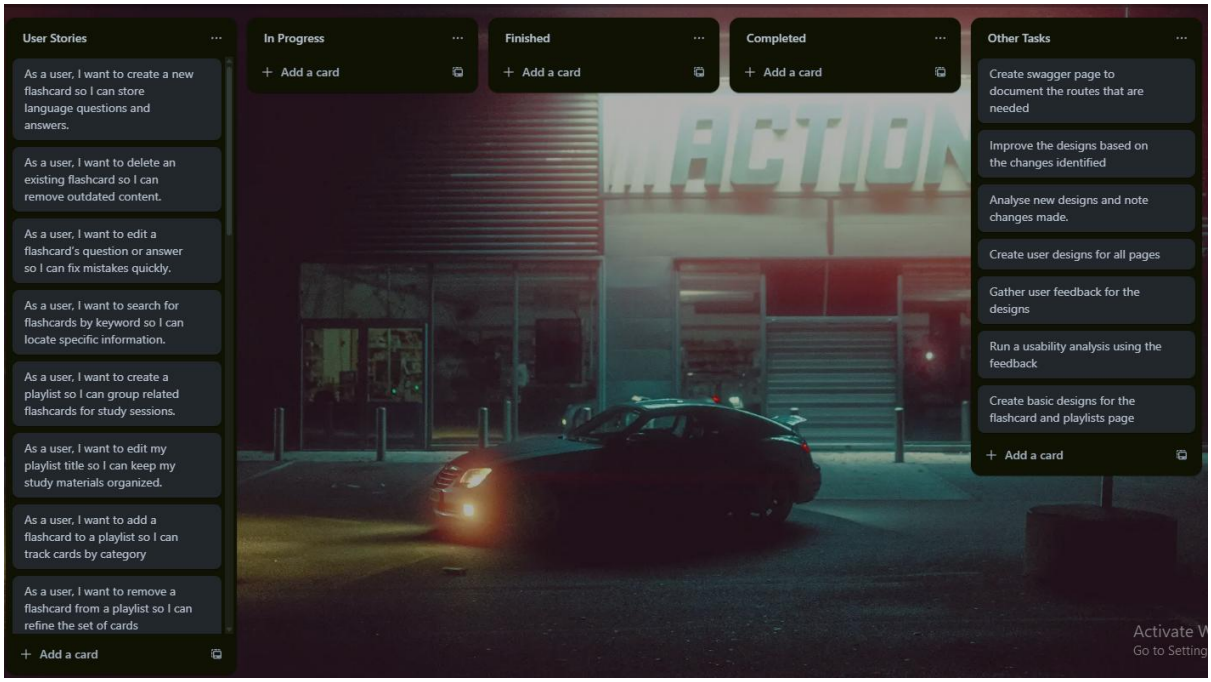
The initial sprint was focused around gathering requirements and planning the scope of the project. I developed user stories and other tasks that would need to be completed in the project adding these to Trello to track my progress effectively. Throughout the development new tasks may be added to increase the requirements.

The design of some of the pages were created using Figma, this is a rough design of what the pages might look like in the application, allowing me to idealise what requirements the program would include.

Here you can see some of the designs that were made at the start.

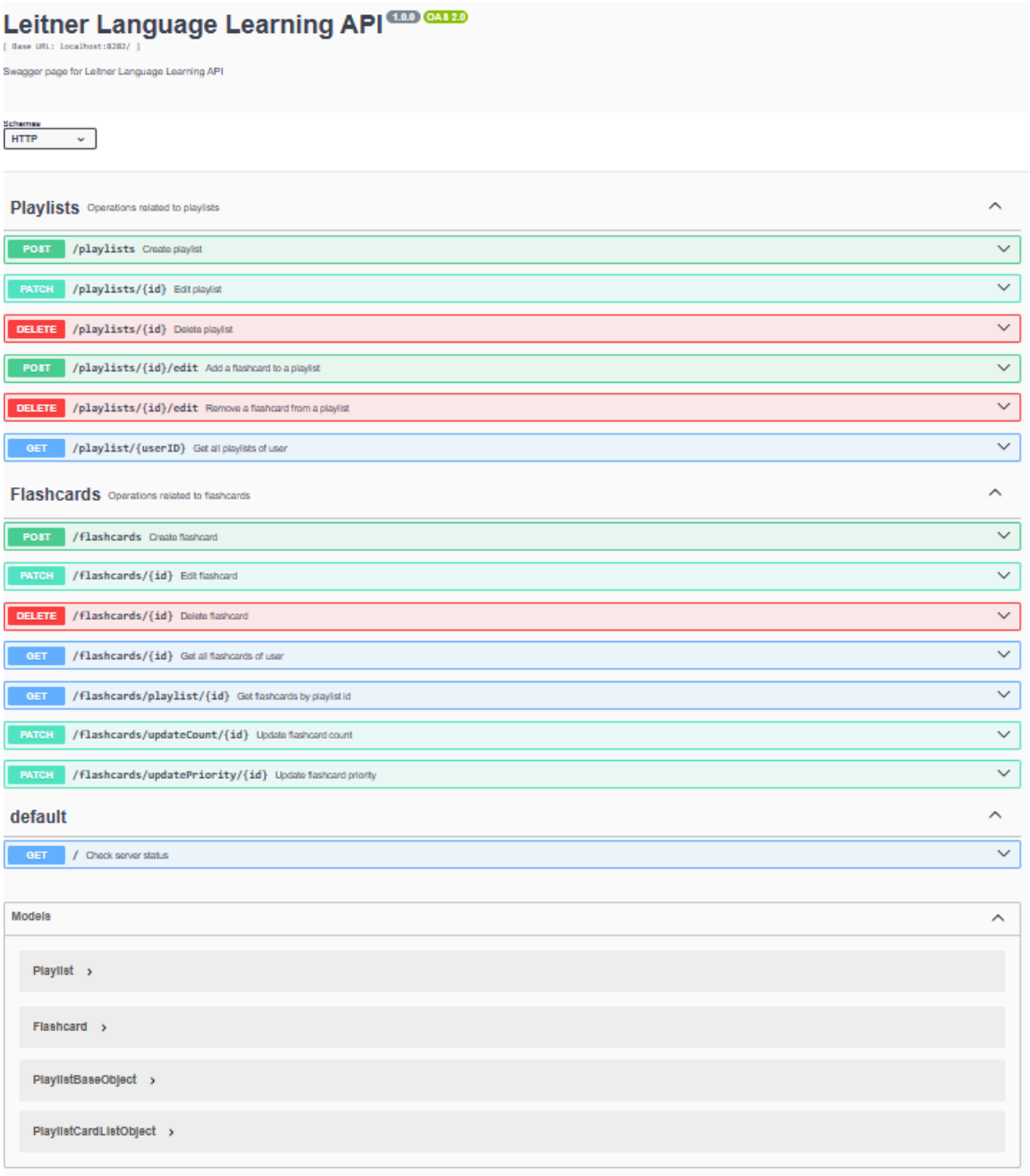


Trello State – Designs in the “other tasks section are complete”



Sprint 2- 27/12/2024- 10/01/2025

Sprint 2 was focused on the documentation of the backend, making sure that all the routes and services that the application would need were documented. This will help during the implementation ensuring that it functions as expected.
To make the documentation of the API, I am using open API documentation, or swagger, here you can see a screenshot of my swagger page:



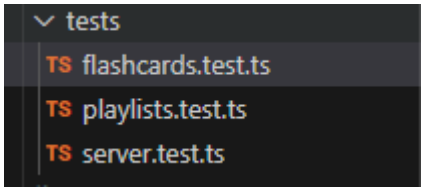
Trello – No changes were made to functionality

Sprint 3- 10/01/2025- 24/01/2025

Sprint 3:

Objectives: Write test files so that I can perform test driven development.

I have written test files for the routes that my API uses:




```
// Test creation of a flashcard
it('should create a new flashcard', async () => {···
});

// Test getting all flashcards
it('should retrieve all flashcards', async () => {···
});


// Test updating a flashcard
it('should update an existing flashcard', async () => {···
});

// Test deleting a flashcard
it('should delete an existing flashcard', async () => {···
});
```

```
it('should create a new playlist', async () => {···
});

it('should fetch all playlists', async () => {···
});


it('should update a playlist', async () => {···
});

it('should delete a playlist', async () => {···
});
```

Currently these do not pass as I have not written the server code.

Trello – No changes were made to functionality

Sprint 4- 24/01/2025- 07/02/2025

Sprint 4:
Objectives:
Finish off user designs
Create feedback form.

Conduct user feedback study with peers and gather feedback.

In this sprint I finished off the UI designs, then gathered feedback on them.

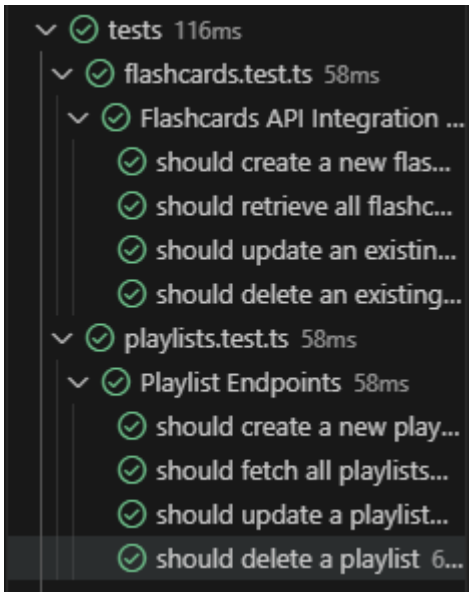
Sprint 5- 07/02/2025- 21/02/2025

Sprint 5:

Objectives:
Implement server code from documentation.

For each endpoint that I defined in the documentation I went one by one and wrote the server code for it, making sure to reference the documentation and making sure that all the test cases pass for each route.

Here you can see the test cases passing after I have written them:



Trello – No changes were made to functionality

Sprint 6- 21/02/2025- 07/03/2025

Sprint 6:

Objectives:

For this sprint I focused on implementing the frontend functionality, translating the designs and implementing the feedback that I have gathered from the peer review and UI feedback.

I will use fake data at the start to make sure that I can focus on developing functionality.

This is the file structure for the frontend:

```
├ app/                          # Main application screens using file-based routing
│  ├ _layout.tsx                # Root layout with tab navigation
│  ├ index.tsx                  # Entry point/welcome screen
│  ├ Homepage.tsx               # Main flashcard study screen
│  ├ Flashcards.tsx             # Flashcard management screen
│  ├ Playlists.tsx              # Playlist listing screen
│  ├ (auth)/                    # Authentication screens
│  │  ├ Login.tsx
│  │  └ Register.tsx
│  └ playlists/                 # Playlist routes
│     ├ _layout.tsx            # Playlist navigation layout
│     └ [id].tsx               # Dynamic playlist detail route
├ assets/                       # Static assets (images, sounds, fonts)
├ components/                   # Reusable UI components
│  ├ Auth.tsx                   # Authentication component
│  ├ Button.tsx                 # Custom button component
│  ├ Feedback.tsx               # Study feedback component
│  ├ FlashCard.tsx              # Flashcard component
│  ├ Input.tsx                  # Custom input component
│  ├ Loading.tsx                # Loading indicator
│  ├ Modal.tsx                  # Modal dialog component
│  ├ Playlist.tsx               # Playlist item component
│  ├ ScreenWrapper.tsx          # Common screen wrapper
│  └ Typo.tsx                   # Typography component
├ constants/                    # App constants
│  ├ index.ts                   # Exported constants
│  └ theme.ts                   # Theme configuration (colors, spacing, etc.)
├ hooks/                        # Custom React hooks
│  ├ useFlashcards.tsx          # Flashcard data management
│  ├ useModalView.tsx           # Modal state management
│  ├ usePanGesture.tsx          # Gesture handling for cards
│  └ usePlaylists.tsx           # Playlist data management
├ utils/                        # Utility functions
│  ├ styling.ts                 # Responsive styling utilities
│  └ supabase.ts                # Database connection
├ app.json                      # Expo app configuration
├ package.json                  # Dependencies and scripts
└ tsconfig.json                 # TypeScript configuration
```

Trello – No changes were made to functionality

Sprint 7- 07/03/2025- 21/03/2025

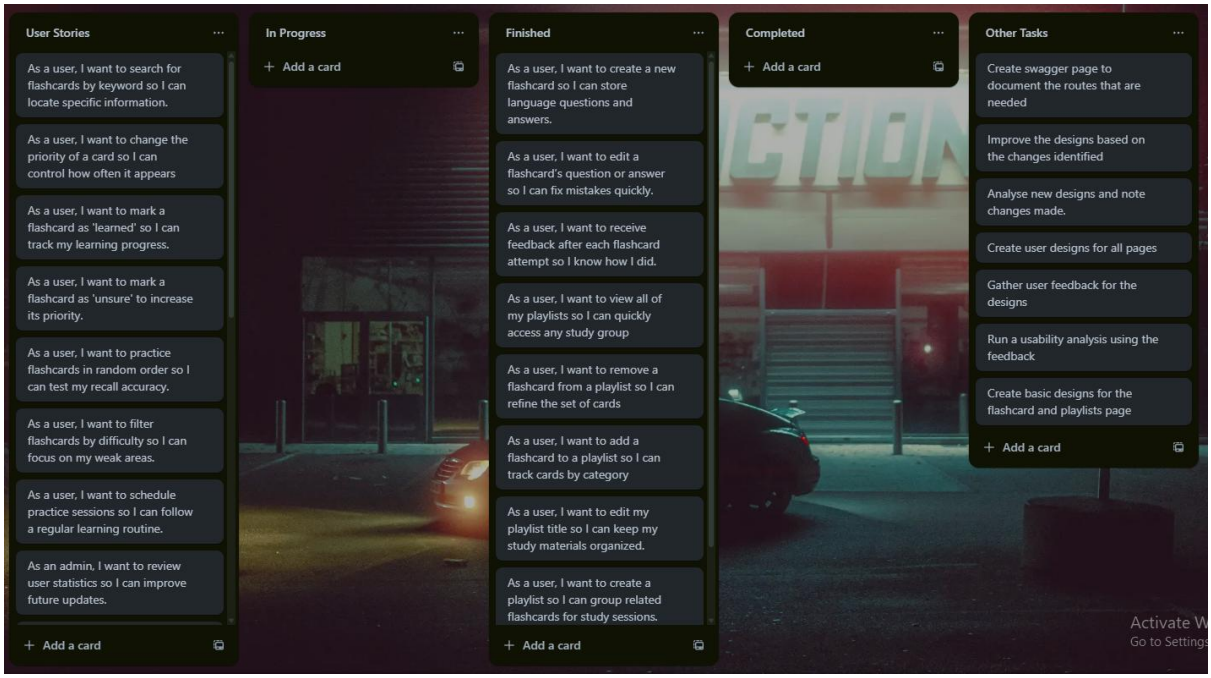
Sprint 7:

Objectives:

Implement server communication with the frontend.

For this sprint I focused on implementing the API communication between the server and the frontend. This will replace the fake data that I was using for the development stage.

Trello -



The features that have been implemented are mainly core features that will meet the MVP.

The features that I have not yet implemented are quality of life features that would make the app better.

Sprint 8- 21/03/2025- 04/04/2025

Sprint 8

Objectives:

This sprint will be focused on making sure that the app is working as intended and that all features have been met.

During this sprint I found a few small bugs that would appear in rare cases, such as allowing bad inputs into fields such as white space characters.

These were not too difficult to fix.

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Appendix A User Guide

To install, simply download the GitHub repository

To run the backend run npm run start

To run the frontend run npm run start

Register an account using credentials

Log in

Appendix C – Third Party Resources Used

React Native

- Bcrypt - https://www.npmjs.com/package/bcrypt
- Cors - https://expressjs.com/en/resources/middleware/cors.html
- Express - https://expressjs.com
- Jsonwebtoken - https://www.npmjs.com/package/jsonwebtoken
- Mongoose - https://mongoosejs.com/
- Supertest - https://www.npmjs.com/package/supertest