Spaced Repetition System

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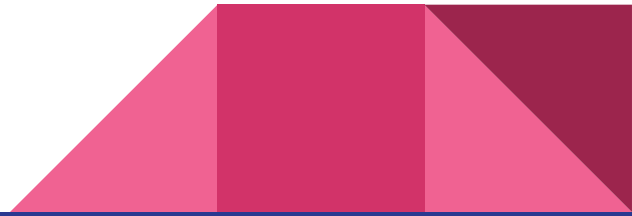
Presentation Outline

In this presentation we will be discussing:

- Goals we set out for our implementation of the Spaced Repetition System
- Work allocation among the team
- Flashcard Framework implementation and UI
- Integration of Spaced Repetition Algorithm and Flashcard Framework



Spaced Repetition System Goals

- Virtual Flashcard System
  - Intuitive UI
  - Has Capabilities to Track Card Difficulty
  - Can Create New Orderings of Cards Accordingly
  - Can Schedule Optimal Future Review Sessions

Team Split

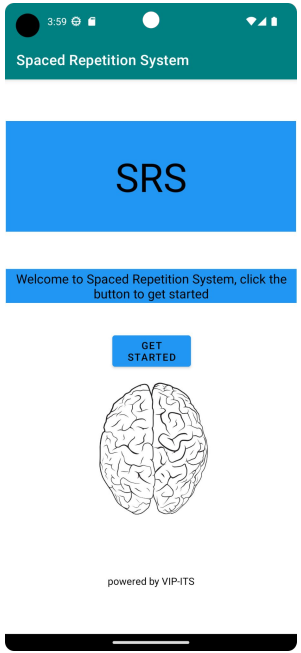
- Work was split into
  - Flashcard Development
    - Finding and Reconfiguring Old Code Base
    - Ani, Sattwik, and Prasad
  - Algorithm Research and Development
    - Chaz and Vinayak

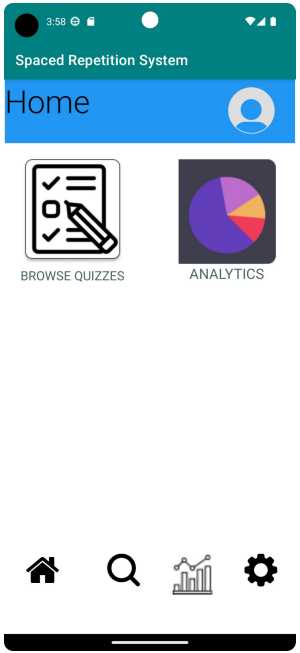
Flashcard Development

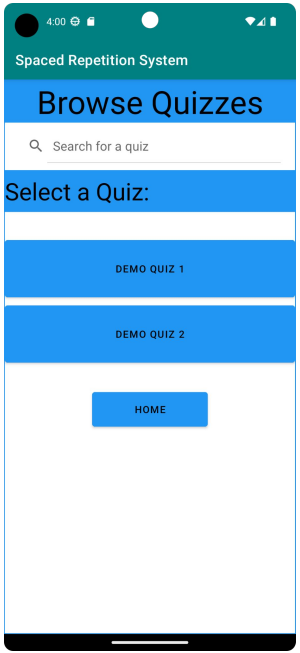
Codebase Reconfiguration

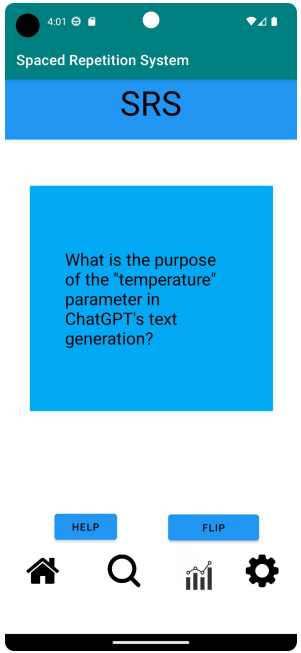
- QuizApp Fall 2022 Repo Used as Starting Point
- Previously Used Toast API to Login
  - Access to the API Key Expired
  - Modified Welcome Page Logic To Circumvent Login
- Previously Included Multiple Choice and Short-Answer
  - Converted to Center Around Flashcard Quizzes

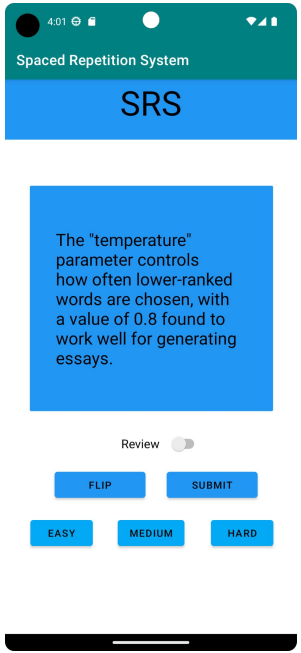
Application Progression

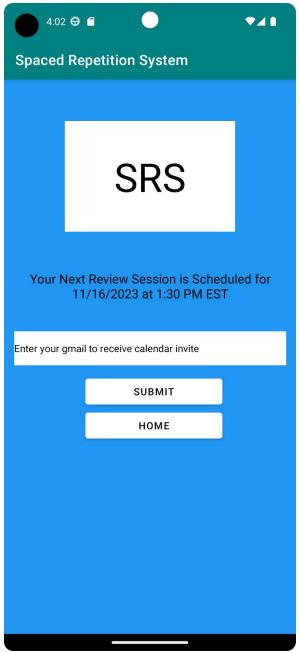






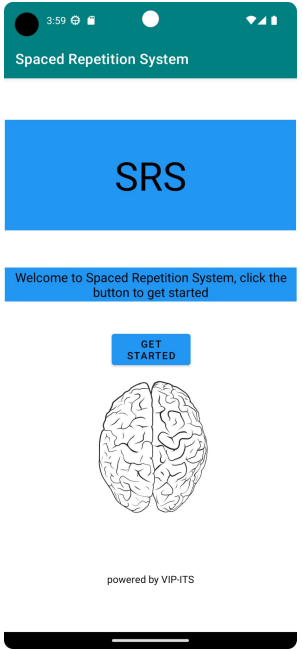


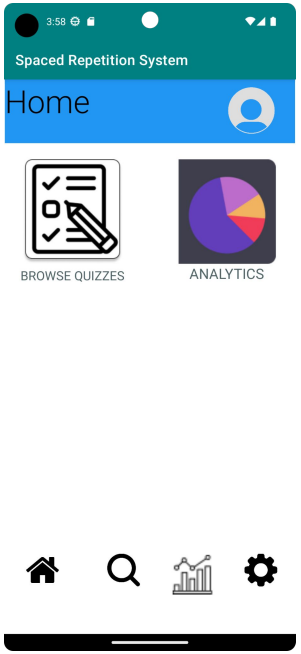




Welcome/Home Screen

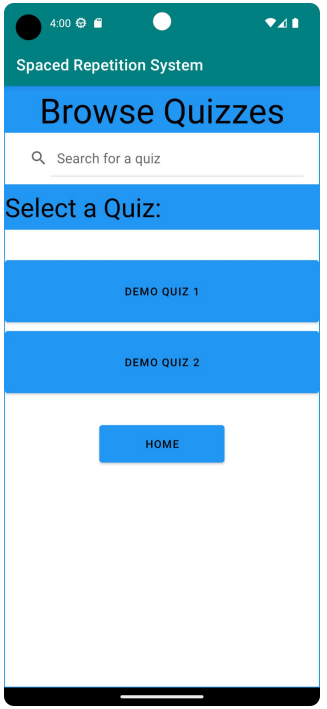
- Design Focused to be Minimalistic
- Browse Quizzes Takes User to Flashcards
- Analytics Currently is Used as a Placeholder
    - Plan to add useful information stored in the spaced repetition algorithm





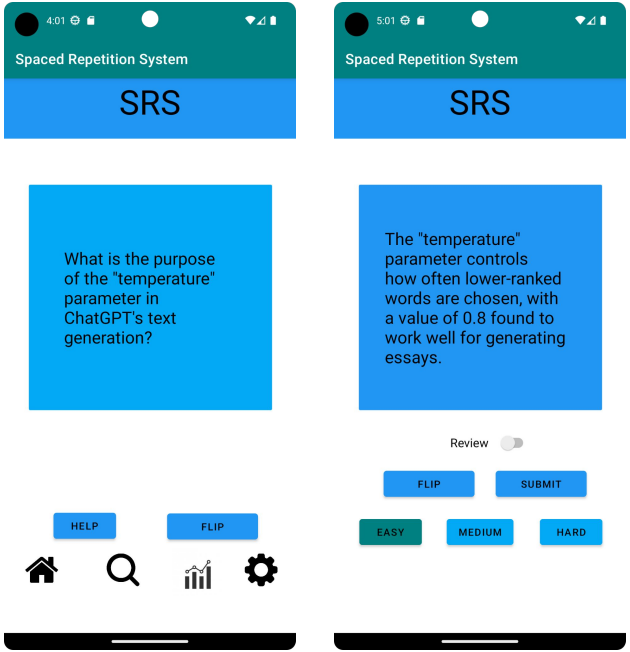
Browse Quizzes

- Allows User to Browse Through Stored Quizzes
- Quizzes will show up when scheduled by the spaced repetition algorithm



Flashcards

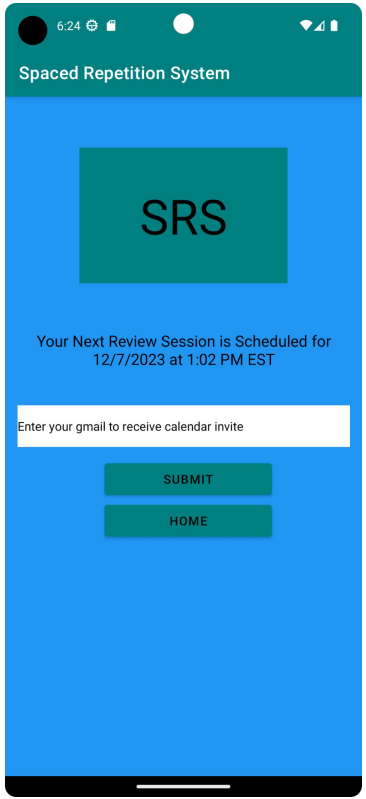
- Flashcards information based on Wolfram's Article written on Chat-GPT
- Help button provides pre-written hint
- Added Features
  - Users cannot advance without clicking a button
  - Button colors changes when clicked
  - Only one button can be selected at a time

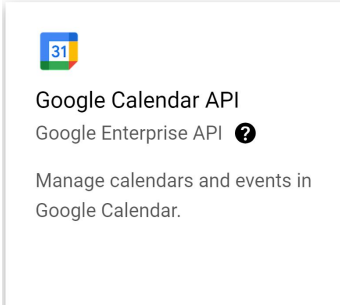


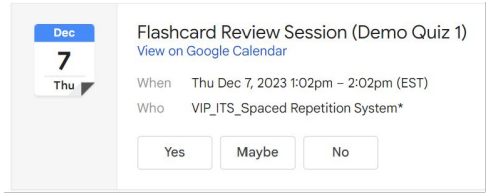
Front Back

Future Session

- Based on time since last review and the most recent user performance, the system schedules a future review session
  - Computation handled by spaced repetition algorithm
- User can enter gmail to receive a google calendar invite to remind user
  - Currently the API is set up to only send invites to a predetermined email address
    - Future semester goal to extend this feature







Spaced Repetition Algorithm Research and Development

How the algorithm works:

- The spaced repetition algorithm works on leveraging the spacing effect, which optimizes and strengthens memory retentions
- The algorithm works on the basis of a key components:
  R: Retrievability (probability of recall)
  S: Stability (interval when R = 90%)
  D: Difficulty (initial difficulty assigned to a flashcard)
  G: Grade (depends on user input)

```
[0.4, 0.6, 2.4, 5.8, 4.93, 0.94, 0.86, 0.01, 1.49, 0.14, 0.94, 2.18, 0.05, 0.34, 1.26, 0.29, 2.61]
```

- Our algorithm also implements the above default parameters that are fine tuned to optimize memory retention.

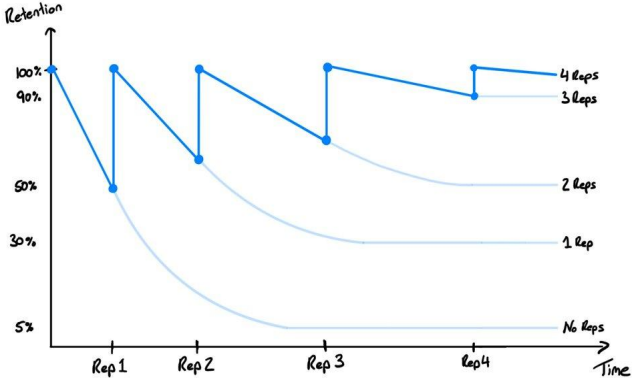
Methods and processes:

```
private double initStability(int r) {
    return Math.max(p.getW()[r - 1], 0.1);
}

private double initDifficulty(int r) {
    return Math.min(Math.max(p.getW()[4] - p.getW()[5] * (r - 3), 1), 10);
}
```

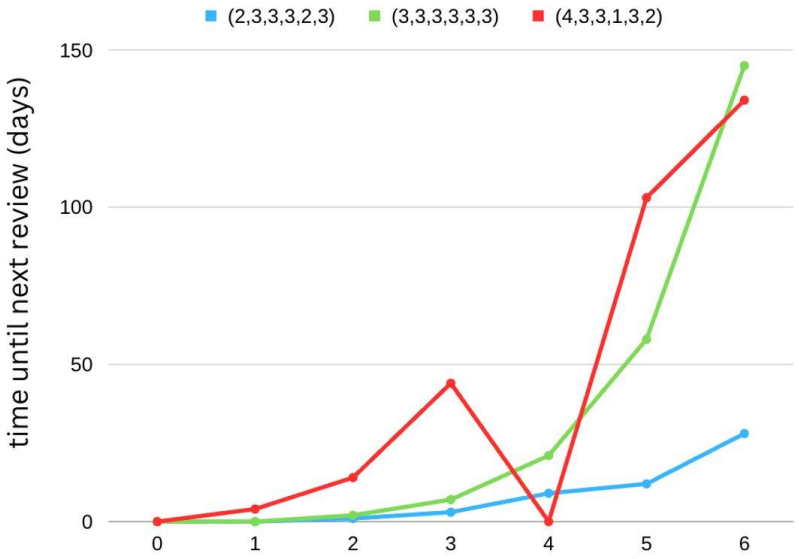
- The initial stability and difficulty are set after the first user rating to prioritize learning by presenting flashcards at an optimal time.
- This approach customizes the review period based on the perceived initial difficulty rated by the user, which allows the algorithm to present flashcards of an appropriate difficulty at the right moment for memory retention

Retrievability and Next Interval



- The entire algorithm is built around the idea that you want your next review to be when your retrievability is at 90% (you have a 90% chance of successfully recalling a card)
- Every successful review increases the time until your retrievability drops down to 90% (stability)

Again: 1, Hard: 2, Good: 3, Easy: 4



- At the moment, your first ever rating of the card determines the initial difficulty of a card
- Starting off with with a better rating means your stability will be higher in the future

Recall and Post-Lapse Stability

$$S_r'(D,S,R,G) = S \cdot (e^{w_8} \cdot (11-D) \cdot S^{-w_9} \cdot (e^{w_{10} \cdot (1-R)} - 1) \cdot w_{15}(\text{if G} = 2) \cdot w_{16}(\text{if G} = 4) + 1).$$

The recall stability refers to the growth in stability after a flashcard is successfully recalled. It is based off the concept that easier material increase in stability faster than material that was initially rated a high difficulty.

$$S_f'(D,S,R) = w_{11} \cdot D^{-w_{12}} \cdot ((S+1)^{w_{13}} - 1) \cdot e^{w_{14} \cdot (1-R)}.$$

The post-lapse stability is calculated based on the default parameters introduced earlier and recalibrates the learning schedule after the user forgets the answer to a flashcard they initially recalled.

Next Steps

- Add key analytics about learning to the analytics tab
  - Derived from spaced repetition algorithm learning
- Extend functionality of the google calendar API to include new users
- Integrate textbook keyword extraction with our flashcards to automatically generate flashcards given a dataset
- Reintroduce Toast API to allow the application to keep track of multiple users
- Introduce an algorithm for the application to determine difficulty of flashcard before user interaction