Project Report

Mobile Flashcard Application with Learning Tracking

(MemCard Project)

COMP 495
Computer & Info Systems Project

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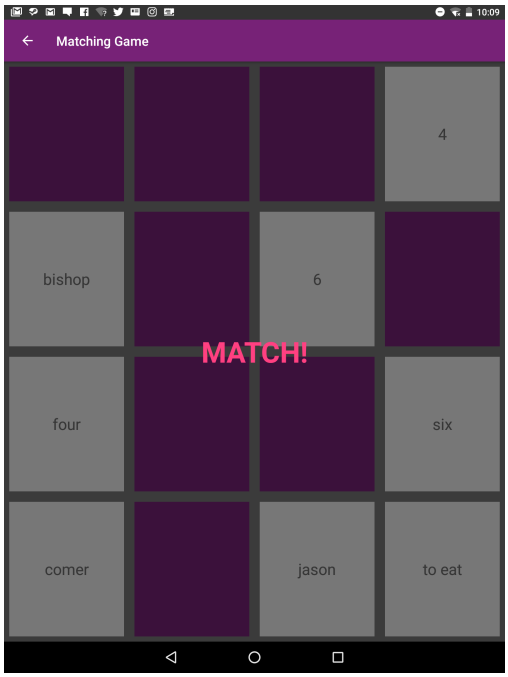
3042012

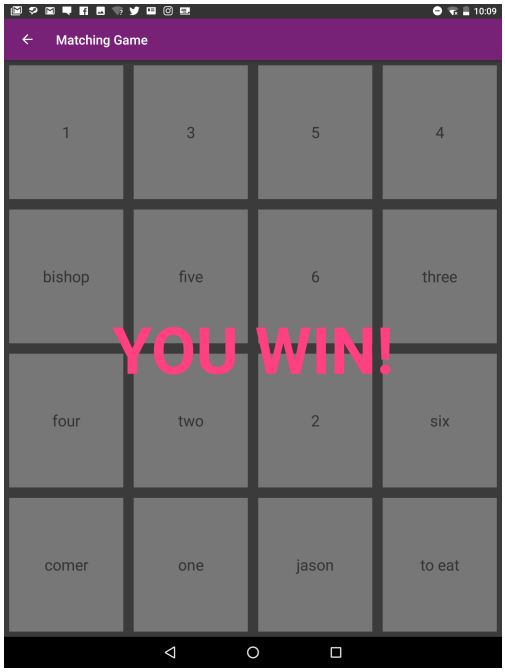
Introduction

The MemCard Project is an Android application that allows users to create flashcards on their mobile device. Flashcards are a common tool to help people learn various subjects from language vocabulary to medical terms. They are an excellent way to learn and retain information, so long as they are studied in a regular, consistent manner. The application helps users to retain information in various ways, providing several options to review their created flashcards.

One helpful way that users can use the application is to create sets. A set is a collection of cards in the application. Users can create their own sets, allowing organization of their flashcards into convenient groups for review and study. Another way that users can review their created cards is through playing the matching game available in the app. The game randomly selects 8 cards from the database, and users have to match the front and back terms of the cards. The game consists of 16 cards all face down. Users flip over a card to see the term, and try to find the matching term from the remaining cards. The user matches cards until all matches are made and the game is over.

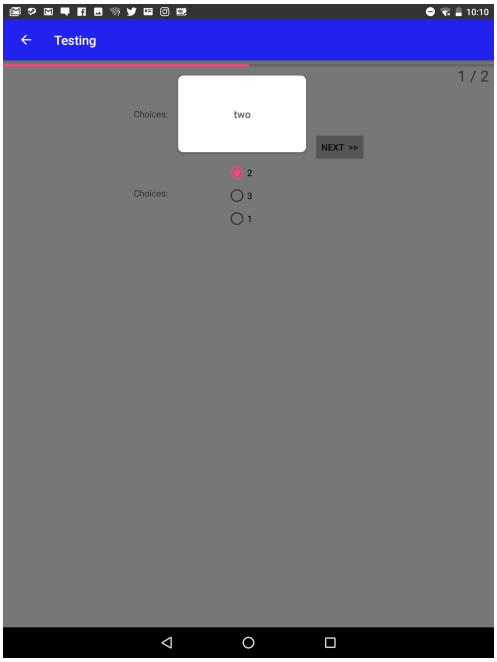


A match is made

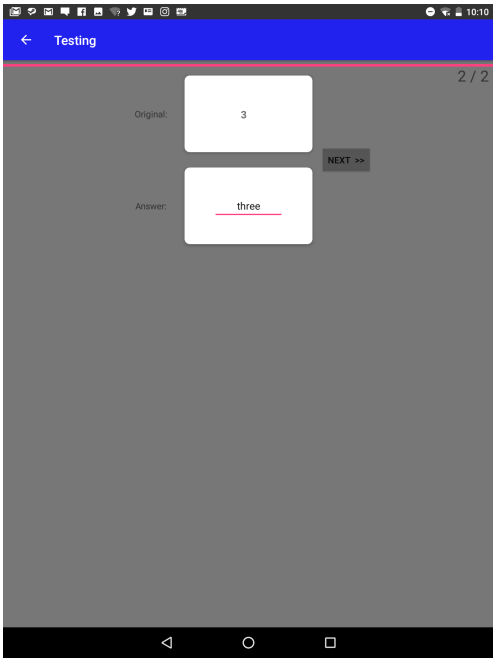


The game is won

The final and most important way for users to retain their flashcard items is through the use of testing. While users are free to look at and review their cards at any time on their own, testing is only available at prescribed intervals. The app uses a simple algorithm to ensure that users can be tested at regular intervals so that the user will properly retain the information. The main idea of the algorithm is to used spaced repetition to ensure that items remain in memory. The idea is that instead of studying items in a bunch, periods of rest in between study sessions helps retain the information. Additionally, the longer the time between sessions, the longer the item will remain in memory. To this end, the application has set testing time intervals for each card. As the user successfully test themselves with each item, the time between tests increases. Once the maximum level is reached, the information is considered learned and no more testing is done.



Multiple choice test question



Standard test question

Project Summary

Project Goals:

As outlined above, the main goal of the project is to create an application that allows users to create and study flashcards on their mobile device, ensuring that they can retain the information they want to store in the app. This main goal can further be broken down into three further sub-goals that to aid in achieving the main goal: ease of use, organization, and retention. The ease of use goal basically follow general user-interface ideals. The goal is to use colour, text, and layout information to help guide users to easily use the application. This allows users to concentrate more on retention and study, instead of becoming frustrated with the use of the application itself. The organization goal is meant to allow users to easily access the items they want in the app. If cards were simply laid out without any organization, finding a specific item to study would be difficult. The final goal of retention is meant to ensure that users remember the items they are putting into the app. The goal here is to have users retain the information better than they would if they were to simply study the information on their own.

Design Rationale:

The design rationale is centered around the ease of use and interface goal outlined above. The app is intended for users to easily navigate through different screens, creating and organizing their flashcard items. Users should always know where they are in the app, and how to get to where they want to go. However, to encourage use and study, the application needs to be interactive, dynamic, and enjoyable to use as well. And since the basic unit of interaction within the app is the flashcard, design and use of these individual units should be of the utmost importance.

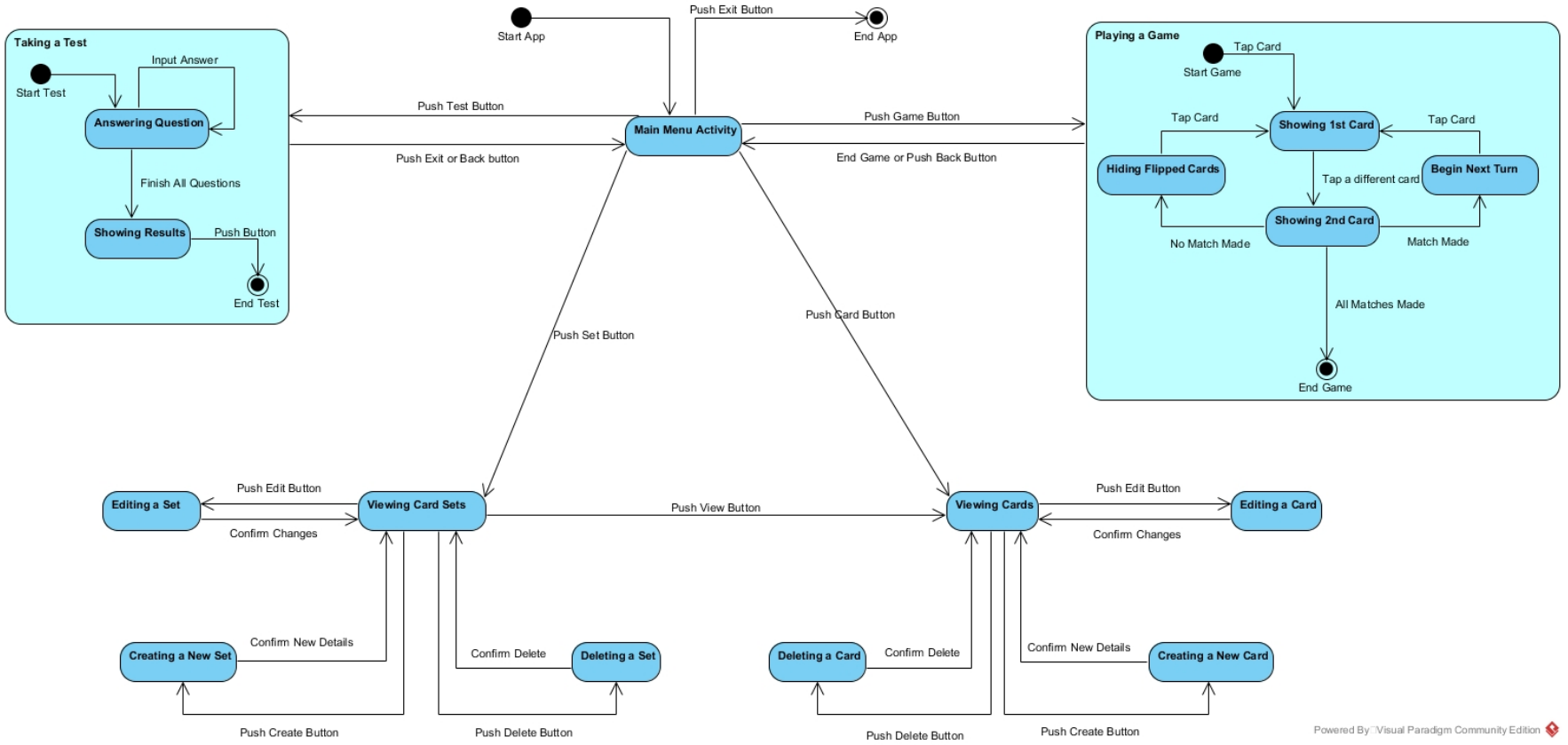
Methods/Design:

Following the design rationale outlined above, the application was developed under a modified waterfall methodology, with each stage of development flowing into the next, but allowing return to previous development stages when necessary. For the first stage of development, the requirements were outlined in the project proposal.

The design stage began a short while later, attempting to follow the design rationale. The first task was to lay out the underlying database design. Only a very simple design was needed, as the main flashcard items make up one table. In keeping with the rationale of ease of use, cards can be organized into sets, which allow the user to group flashcards based on whichever criteria they wish. These sets comprise another table in the database, with the following design:

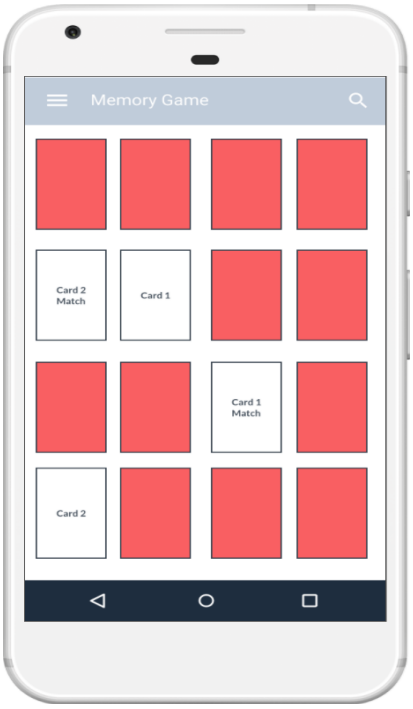
Database model

Next, the user interface was designed, again attempting to hold to the design rationale outlined. To keep things simple, and to conform to the database model, three screens were originally planned. The main screen as an entry point for the application, a screen to view the cards, and a screen to view the sets. Since the main screen is the entry point for the app, it should provide easy access to the other areas. Simple, large buttons allow users to quickly and easily navigate. The cards and sets screens provide simple grids/lists of items for users to scroll through the items they have created in the database. Each item in these lists were designed to provide information to the user in an easily understandable format. The basic outline of these screens were designed as follows:



MemCards activity diagram

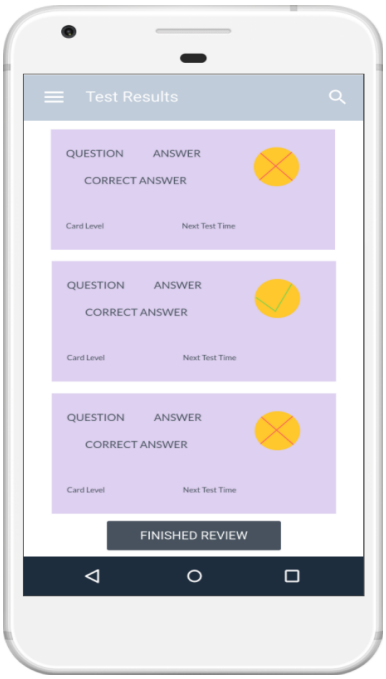
With the basic layout covered, there was still one major aspect of the design goals to be covered. How could the app make interaction more fun and appealing, encouraging review and study? Furthermore, in accordance with the project goals how can the app help ensure that users retain the information they intend to? These questions were addressed by the creation of two additional screens for the application.



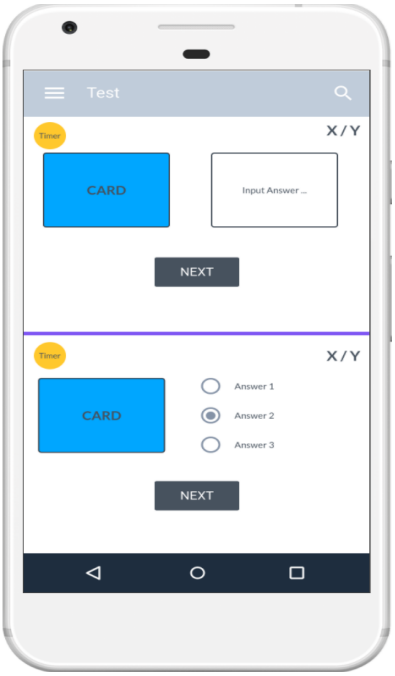
Game Design

A simple solution to the first question, a game would make the app more appealing and fun. A simple game idea that is often used with flashcards is the 'Memory' or 'Concentration' card game**. The game consists of matching pairs of cards face down. Pairs of cards are flipped over to see if they match, and the game continues until all matches are made. The information on the cards in this case would be the matching front and back terms of the flashcards. The design for this game follows the classical game layout, with a total of 16 pieces (or 8 flashcards) used.

Next, to fulfill the goal of aiding users with retention, a testing screen was required. Users need to be regularly tested to ensure they remember the items on their flashcards. While it is always up to the user how often they wish to use the application itself, the app helps users by providing a regular testing schedule for each card item. However, the test should not be too complicated or difficult, so two question types were developed: The first is a simple input of the term from the other side of the flashcard. For example, if the user was shown the front of the card, they would be asked to input the term on the back of the card, and vice versa. Secondly, a multiple choice type question was used, where users are shown either the front or back of the card, and asked to choose the correct answer from a list of possible answers. The outline for these test types are below, along with the outlive for the final results:

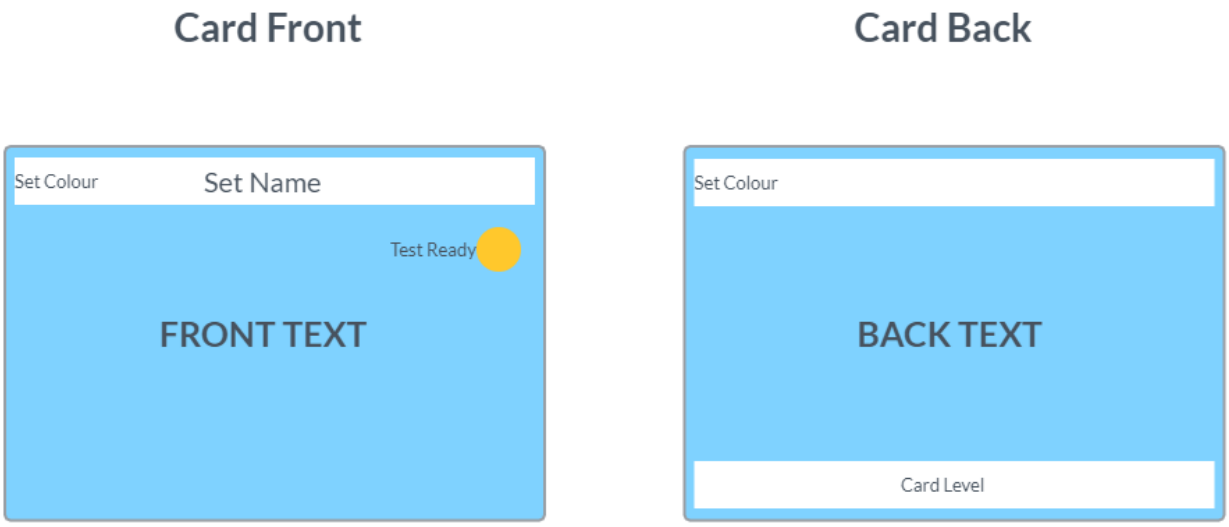


Test Results Design



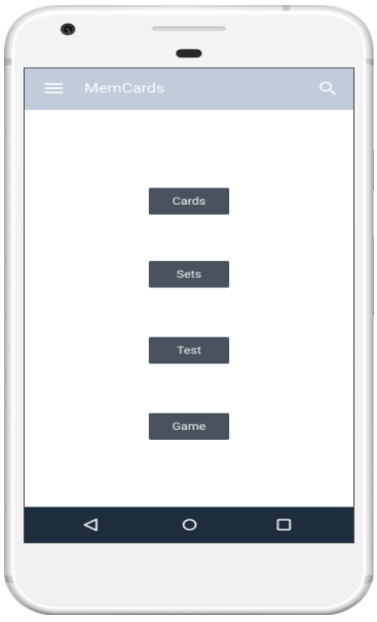
Test Question Design

Next and most importantly, the flashcard itself required careful thought in design, as it is the main reason for the application's existence. As such, it should be pleasant to look at and provide information without being overwhelming. The design went through several iterations, with the need to follow the goals and rationale driving different design concepts. The final iteration tries to present as much information as possible, while still keeping the focus on the front and back terms as the main feature of the flashcards, but also providing other information as well.

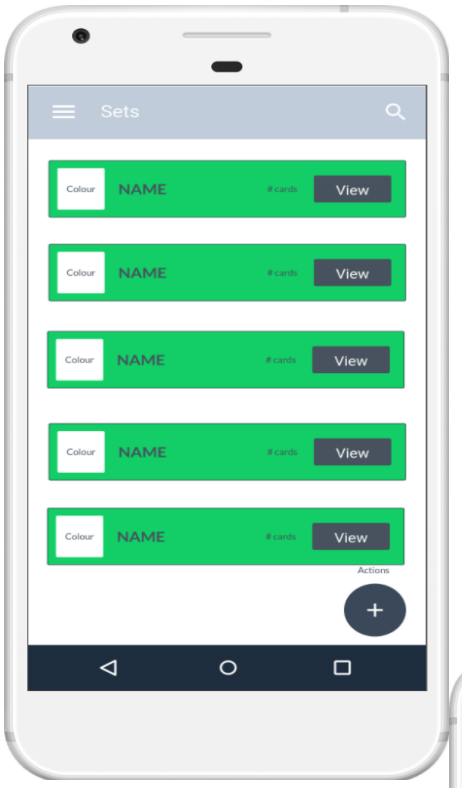


Flashcard Designs

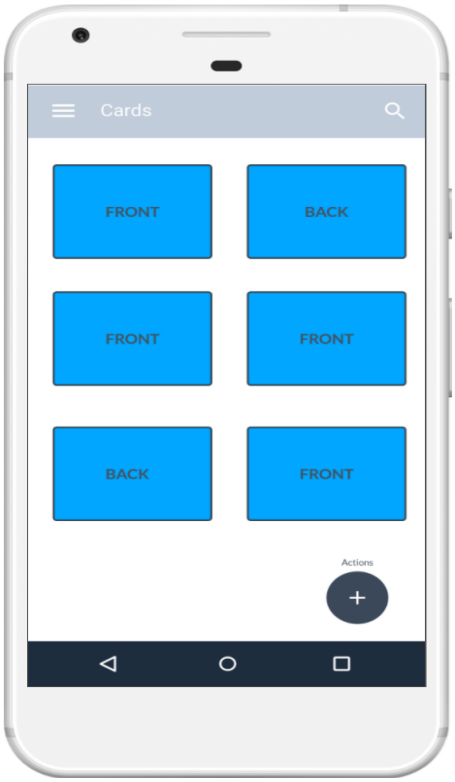
Finally, here are the other design layouts for the various screens of the application:



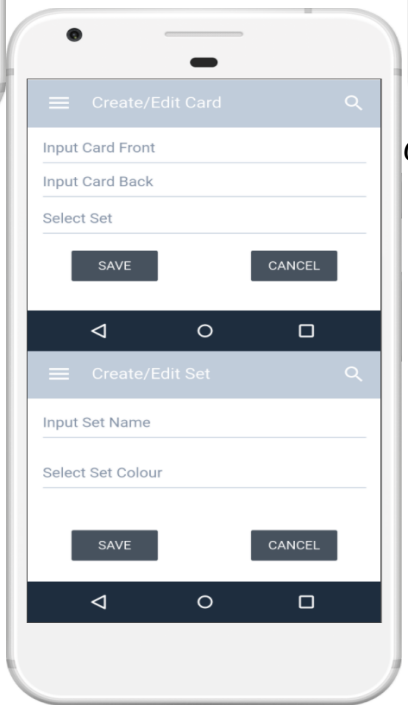
Main screen design



Set viewer design



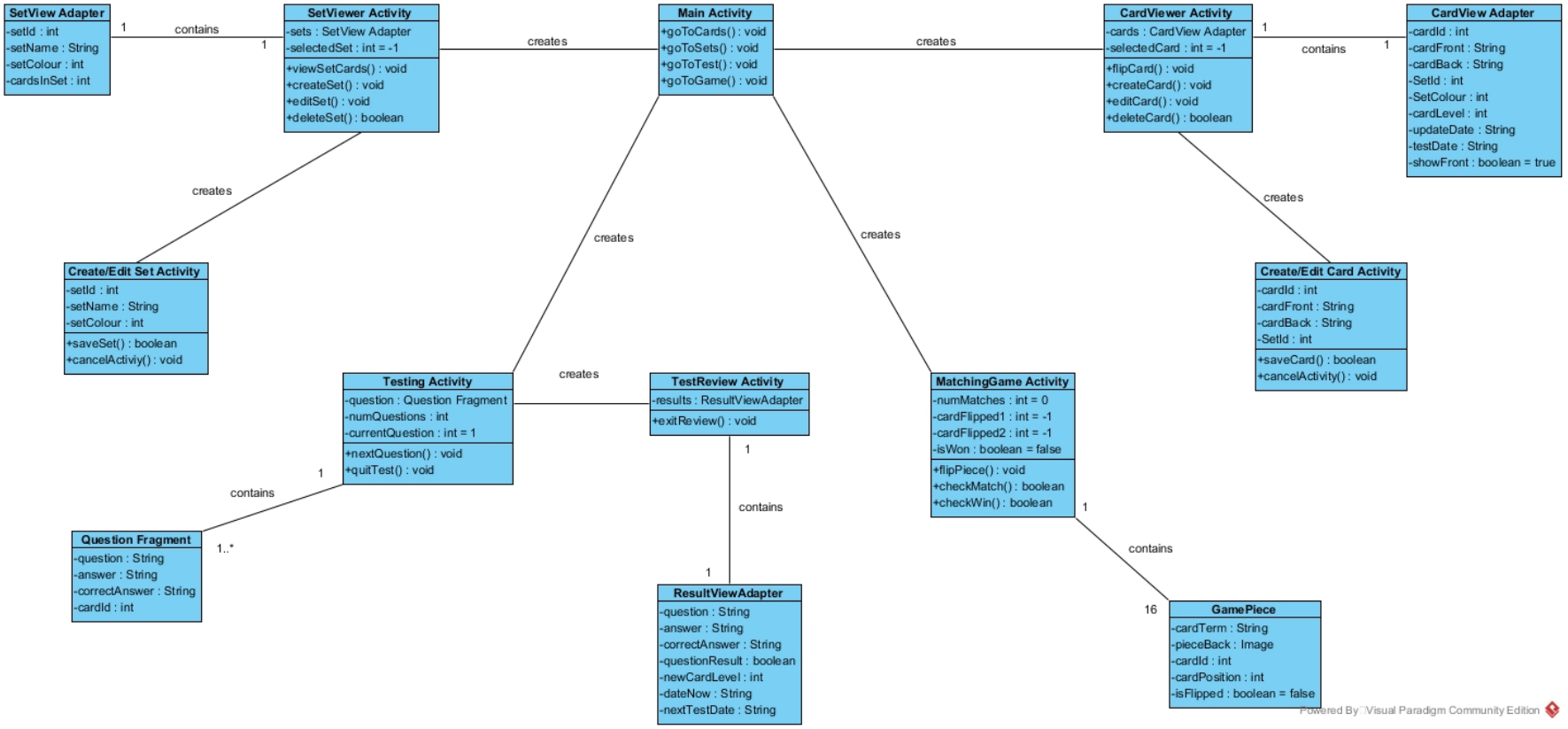
Card viewer design



Creation screen designs

Implementation:

This project was implemented as an Android application, developed through the use of the Android Studio IDE and Android development SDK. This means that several layouts were configured with XML files, and one class representing each activity. Several more supporting classes were created to develop the activities as well. With a main screen and four additional main activities, the basic activity diagram is as follows:



MemCards class diagram

However, during development of the testing activity a slightly different approach was taken. A pre-testing phase was added, allowing users to select which cards they would like to test themselves on. This was needed to prevent tests from becoming too long, and gives users the chance to study what they feel is most important.

A key factor in the implementation was to develop the algorithm that determines when the user should test themselves on the flashcard items. Too little time between testing phases would mean that users are not maximizing their retention capabilities. Yet too much time between testing phases increases the possibility that the item will be forgotten. In keeping with the study findings outlined in the project proposal, a staggered testing method was developed. Cards are automatically assigned a level of 1 when created. Each time the user successfully passes a test, the card is level up, and the time until the next test is increased. The maximum level for each card is level 6, where the item is considered to be permanently stored in long term memory. The testing schedule is designed as follows:

Level 1: 12 hours → Level 2: 1 day → Level 3: 3 days → Level 4: 1 week → Level 5: 2 weeks

However, if the user fails the test, the card is kept at the same level, and the test time is reset to the value of that level. Users cannot level down, no matter how many times the test is failed. As mentioned the staggered and increasing time between tests aids in memory retention and ensures that items are not studied too often.

One more key design decision developed in implementation was to avoid the use of classes created for cards and sets. This information is stored in the database to preserve the structure of these items. The classes are only used in adapters when displaying the list of items to the users.

Lastly, the final implementation was the development of the UI colour scheme. Originally, I intended to keep the standard Android application colours, but it turned out they were limiting somewhat. Every screen looked similar to one another, and the white background did not help distinguish individual items such as cards or lists when they were presented on screen. Therefore the dark theme was developed, which I find is not only easier on the eyes, but provides a good contrast to the white background of set and card list items. Additionally, each section of the app was given its own distinct highlight colour. Bold colours were chosen, and each section has it's action bar highlighted with those colours, allowing users to quickly identify which section of the app they are currently using. These colours are also reflected in the buttons of the main menu, so that users can visually associate a particular colour with a particular activity, aiding in navigation.

Results:

On a personal note, I am quite pleased with the final results of the application. I feel it turned out better than I had planned and visualized. This is partly due to the ease of tools in the Android Studio IDE, as it allows for easy layout and customizability options. However, I feel that my design choices help contribute to the overall look and feel, and make the app feel cohesive and professional. I personally enjoy using the app, and I hope that other users do so as well.

The interface is clean and easy to use. Most of the interaction consists of button presses for navigation, such as the buttons on the main menu, or the standard Android back button. Users can also tap on cards to flip them over in a quick animation, which makes them interactive and dynamic, complying with the design goals and rationale. The same goes for the memory game included in the app, using the same flip animations and providing a fun way for users to study.

However, the least effective result is unfortunately with the cards themselves. There is a lot of information to present, and while I tried to keep things as concise as possible, there is still some clutter. However, I feel that to present too much information to the user is too overwhelming. The card design tries to strike a balance between these two conflicting concepts. It presents as much information as possible, while trying to remain simple and streamlined. While I feel this goal was achieved in accordance with the design principles, there may still be a better way to accomplish this goal.

Discussion

Evaluation:

Evaluation of this app was conducted after the full implementation and testing phases were completed. I tested the app myself and had a friend use the application while I observed and asked questions, without aiding them unless specifically requested to do so. The evaluation criteria fall into three main categories:

1. User Interface
2. Recall effectiveness
3. Overall enjoyment

In the user interface category, the evaluation was considered to be successful if the application was easy to navigate, easy to understand what was being presented to the user, and ease of application interaction. Tests were conducted using sample cards and sets provided with the application, as well as any user created items during the evaluation process. After using the app for a while, I asked myself and my test subject the following questions asking for a numerical rating out of 5 for each:

Question	Developer Response	Test Subject Response
1. How well could you navigate through the various application activities?	5	5
2. How well did you understand the information presented to you?	4	4
3. How would you rate the presentation of set information?	5	5
4. How well would you rate the presentation of card information?	3	4
5. How well were the test questions presented?	5	5
6. How well was information organized and presented to you in the application overall?	4	5
7. How responsive was the application?	5	5

From the results of these questions, it appears that the user interface is an overall success. As discussed earlier in the report, I gave question 4 a lower overall score due to my issues with presentation of the card information. This also had an effect on the overall score. My test subject gave a lower score to question 4 for similar reasons, saying the cards were a bit small, and therefore a little cluttered. Also, question 2 was a little lower because she had never used the application before, so needed some time to familiarize with what was being presented.

For the recall effectiveness category, I created extra sample cards to be tested. While the evaluation phase was not long enough to test long term effectiveness, short term results can hopefully be indicative of these results. Sample cards were made using German/English word pairs, a language with which my test subject and I have very little familiarity. The information was tested using an oral quiz after the other phases of the evaluation were carried out. This ensures there were other activities and time in between immediate use of the application and the test. There were four of these sample cards in all, and the results are as follows:

German word	English word	Developer correct	Test Subject Correct
rot	red	✓	✓
wasser	water	✓	✓
gehen	walk	✓	✗
hai	shark	✓	✓
kartoffel	potato	✓	✓
stark	strong	✓	✓

In this small evaluation, it seems that overall recall has gone well. However, there are some severe limitations to this test other than the only measuring the short term effects. For my personal results, I did randomly select the words, but I was much more familiar with them through development of the evaluation. I am sure this had significant effects on my recall. Likewise, the test subject marks were skewed higher by the fact that she had time to study and was tested right away. In normal use of the application, the first test does not occur until at least twelve hours after the card has first been created. The only way to properly test the actual effectiveness of this application would be through a controlled long term experiment, which is not feasible at this time.

In the final category, the enjoyment was measured in a similar manner to the user interface evaluation. Questions were asked about the various aspects of the app, and results ranked numerically out of 5.

Question	Developer Response	Test Subject Response
1. How well did you enjoy using the cards?	5	5
2. How much did you enjoy the matching game?	3	5
3. How well did you enjoy the testing process?	4	5
4. How much did you like the colour scheme?	5	4
5. How well did you enjoy using the application overall?	5	5
6. How likely would you be to recommend this application to your friends or family?	4	5

According to the results, the application is enjoyable overall. The test subject said she enjoyed the application, giving the colour scheme a lower score because she did not prefer the darker theme and also thought the regular grey buttons were ugly. My results were lower in several of the categories. I feel that matching game can be enjoyable, but I have used it several times and it can be repetitive after repeated use. As for the testing process, I would like to see more interesting testing methods as I don't really enjoy typing on any mobile device, and multiple choice is always boring in my opinion. Some sort of spoken option for responses would be really cool, but far beyond my abilities to develop at this point. Finally, I wouldn't recommend this application fully because I feel it could be improved.

One final question was asked for the evaluation process: Are there any suggestions you have to improve your enjoyment or use of the application? My test subject suggested that more games could be made available. My answers to this question are in the conclusion below.

Conclusion:

Overall, I feel that all stages of the development process have turned out successfully. The app is fairly simple to use, and is often somewhat intuitive, even if the user has not used it before. Navigation through the app is straightforward and simple and using it is not unpleasant, and as the evaluation results show, it can even be enjoyable!

Yet this does not mean that there are not drawbacks and limitations to the application. One major flaw is the evaluation process itself. Being conducted with only two people, the sample size is rather small. There is also a lot of bias on my part because I am the developer of the application. The test subject, being a close friend of mine, is also biased towards more positive results. Unfortunately, I do not have the resources to properly expand the evaluation process at this time. One solution, which I hope to implement in the future, is to release the application to the Google Play store, where the application can be available to all, and people can offer their opinions and feedback through the Google's rating system.

Even without this feedback though, I recognize many improvements that can be made to the app. Making a variety of games as my test subject suggested is one option of course, but even the memory game that is currently there can be improved. As of now, the game just randomly selects cards from the database. Instead of this simple selection process, the application could select the least studied cards, or allow users to select a particular set of cards for study.

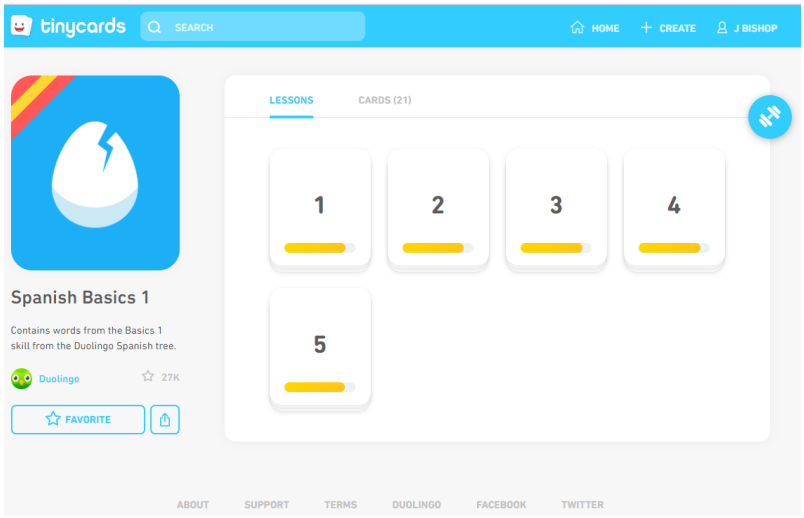
However, the game portion of the application is not the main focus, and there are other improvements that can be made in more critical areas. For instance, the problem of card presentation has been discussed above. Cards could also be improved in their organization. While users can view their sets, when they view all cards, the cards appear in order of their creation. If this list grows large, it could be difficult to find a particular card in a massive list. There could be alternate options for card organization, one example being an alphabetical organization. Set organization could be improved in the same manner, although the list of sets is unlikely to be anywhere near as large as the number of cards. Furthermore, sets could be uniquely improved by showing how many cards are ready to test in each set. A small change that could provide a bit of useful short hand information to the user.

One other useful bit of card information that could be offered is the next testing date for each card. Yet this would contribute to even more clutter in the card interface. I purposefully left this information out of the card interface for that reason, only highlighting if the card is available for testing at all. However, this information could be presented elsewhere, a likely candidate being the pre-test phase. Cards that are unavailable for testing could be greyed out and unselectable, while still presenting the information to the user if they wish to find it. However, the obfuscation of this information may also be helpful in some ways, as the user will have to come back to the application to check for testable cards. This will increase their time using the app, and perhaps lead to more study overall in an indirect fashion.

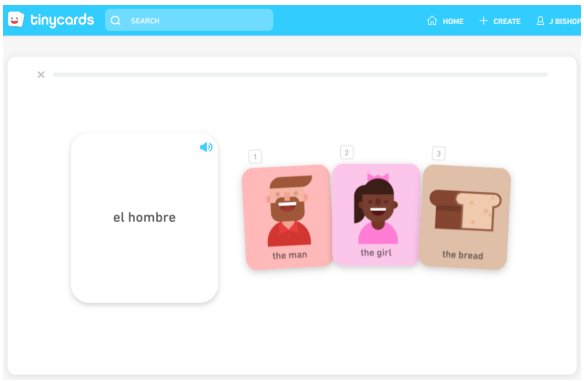
Under the hood, in terms of the actual code, there are also improvements to be made. The most significant of which is database access. Currently, the database is accessed on the same thread as the running application. For small sets of cards this is not an issue. However, if the number of cards grows to be quite large, there could be quite a dip in app responsiveness as the user will have to wait for items to load. Moving the database access to another thread would make the UI more responsive.

One last unique item to consider happened during the final phases of application development. The Duolingo company released their own flashcard application! I have had some brief time with the application, called TinyCards, and find that it seems to follow remarkably similar design ideals and goals. Users can create their own sets of cards, in addition to the many language cards available from the Duolingo language learning application. Cards are organized into sets, and even sets within sets. Cards are tested in the same manner, either typing in an answer or choosing from a multiple choice list. Finally, while users can study the cards at any time, each subset also has a progress bar, indicating that cards need to be tested, and they don't show the testing date either.

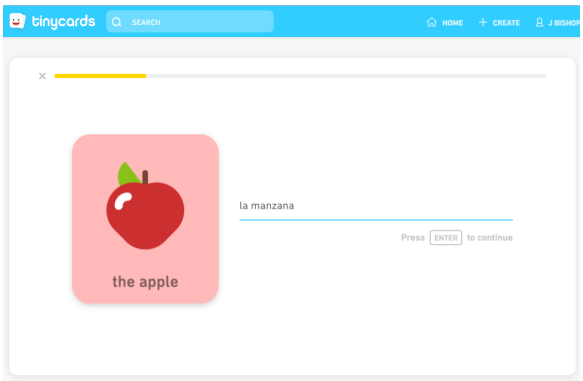
There are also some improvements to my ideas that the TinyCards application has implemented. First of all, my application does not allow for any errors in spelling, while the Duolingo version is more forgiving. They also allow the user the option of marking the card correct. While this seems odd at first, upon using the app I actually found this option quite useful. Sometimes I would enter a perfectly valid synonym for a word on the flashcard, when the application was expecting a specific term. I could mark the answer correct if I felt that my answer was indeed correct. However, I could also see this option being easily abused.



TinyCards sets



TinyCards multiple choice question



TinyCards normal test question

Despite the number of improvements and drawbacks I have mentioned, and despite the fact that there is now a competing app on the market from an established company, I still feel that the development process has been an overall success. I hope to make some improvements and release it for use on Android devices.