F.R.E.D.

Final Design Report Volume 1: Executive Summary

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Executive Summary

Fifty-five million people in the world suffer from some form of dementia, which translates to $1.3 trillion dollars in global economic costs. Fifty percent of these costs are attributed to informal caregivers (such as family members and close friends) who provide an average of five hours of care and supervision per day. In addition to the financial costs, there are significant emotional costs as well. A common side effect of Alzheimer's disease and related dementia (ADRD) that is not often discussed are feelings of loneliness and isolation, for people with the disease and caregivers alike. In recognition of the need for an innovative and low-cost solution to the rising cases of ADRD, the sponsors One UT & UTK Global Catalyst Grant are funding a project led by professor Dr. Zhao that aims to improve the lives of individuals living with ADRD and their caregivers. During his time at the University of Tennessee, Dr. Zhao developed a social robot prototype, named FRED, which stands for Friendly Robot to Ease Dementia. However, due to high manufacturing costs and a high barrier to entry, Dr. Zhao is unable to get his product to market in a timely manner. Therefore, the objective of the FRED project is to develop a mobile application ready for commercialization as an extension of previous work done on the FRED robot.

The app aims to assist individuals with ADRD and their caregivers by providing them with the unique resources they need. NOVI has created a singular app with two main user profiles: a primary user profile for the person with dementia and a caregiver profile for their caregiver, most likely a family member. On the primary user side, the app offers daily support, cognitive stimulation, and companionship for the user by providing a wide range of functions, including personalized reminders, a task planner, customizable games, and an AI chatbot for companionship. On the caregiver side, the app provides users with features catered towards their needs, including: courses and information on ADRD and how to care for people with the disease; updates on their loved one, such as activity levels, location, and notes put in by other caregivers; self-care features like guided meditation, journaling, and personal reminders; finally, a community page where caregivers can see local events and connect with other caregivers. However, for the scope of this project and the team's limited resources, only the primary user side will be fully coded and functional. The caregiver side will only be designed in Figma, a commonly used graphic design software that can be used to create web and digital content.

Through user surveys and technical measurements, NOVI has determined the FRED app sufficiently meets user needs at this stage of the development process. It is currently still in the prototype stage, but with funding from the SBIR, NOVI is confident that with some further development, this product will make a huge impact on people's lives.

The NOVI team recommends that this project be kept on for a future senior design team so that a fully functional app, with both primary user and caregiver profiles, can be developed and put into the hands of those who need it most. Additionally, for Dr. Zhao, we recommend he create his company over the summer so that the next senior design team can submit the SBIR proposal and get funding for him within a year.

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List of Terms and Abbreviations

AI	Artificial Intelligence. A field of computer science focused on creating systems and machines that can perform tasks typically requiring human intelligence, such as learning, problem-solving, and decision-making.
API	Application Programming Interface. A software intermediary that allows two applications to talk to each other and share data within and across organizations.
ADRD	Alzheimer's Disease and Related Dementias. The broad range of neurodegenerative diseases fall under this category.
ISD	Interdisciplinary Senior Design. An educational program at the University of Tennessee where students work with companies to develop industrial and commercial prototypes.
MVP	Minimal Viable Product. A version of a product with just enough features to be usable by early customers who can then provide feedback for future product development.
PWD	Person With Dementia. A person living with Alzheimer's disease or related dementias.
SBIR	Small Business Innovation Research. Programs to fund a diverse portfolio of startups and small businesses across technology areas and markets to stimulate technological innovation, meet Federal research and development needs, and increase commercialization to transition research and development into impact.
UX/UI	User Experience / User Interface. User experience relates to how a user feels whenever they interact with a product or service. User interface refers to the touchpoints a person uses to engage with a digital product.

1. Introduction

Fifty-five million people in the world suffer from some form of dementia, which translates to $1.3 trillion in global economic costs [1]. Fifty percent of these costs are attributed to informal caregivers (such as family members and close friends) who provide an average of five hours of care and supervision per day. In addition to the financial costs, there are significant emotional costs as well. A common side effect of Alzheimer's disease and related dementia (ADRD) that is not often discussed are feelings of loneliness and isolation, for people with the disease and caregivers alike. There is a need for an innovative and low-cost solution to ease the burden of care and enhance the lives of individuals with ADRD. Team NOVI has created an app that aims to assist individuals with ADRD and their caregivers by providing them with the unique resources they need. NOVI has created a singular app with two main user profiles: a primary user profile for the person with dementia and a caregiver profile for their caregiver, most likely a family member.

The following section includes an overview of NOVI's design for the FRED App. Here, NOVI walks through the main features included in the two sides of the app, namely the patient with dementia (PWD) side and the caregiver side. Each side is described through screenshots of the home screen, a brief description of features, and a user flow diagram that walks through how users will interact with the app.

1.1 PWD Home Screen

Figure 1 shows the original home screen for the PWD side of the FRED app from the Figma design. The main features to take note of include the carousel in the middle of the screen, where users can swipe to discover the main functionalities of the application. These include games, reminders, and the FRED chatbot. The games were chosen to provide users with cognitive stimulation and entertainment. The task planner and reminder features were included to help users take control of their schedules and stay organized. Finally, the chatbot was included to act as a personal assistant to users. It is designed to answer any questions users may have and stimulate conversation, which is especially important for people with ADRD since they often lack social engagement. This layout was designed to be like the original FRED robot to have a consistent approach to the app's design.

Figure 1: PWD Home Screen from Figma.

1.2 **High-Level Architecture of PWD**

Figure 2 depicts the high-level architecture of the PWD side of the app through a user flow diagram, showing how users will navigate through the app. Light purple rectangles represent the different screens of the app, while blue diamonds represent actions taken by the user, and finally, orange ovals represent questions that need to be answered to determine the user's path through the app.

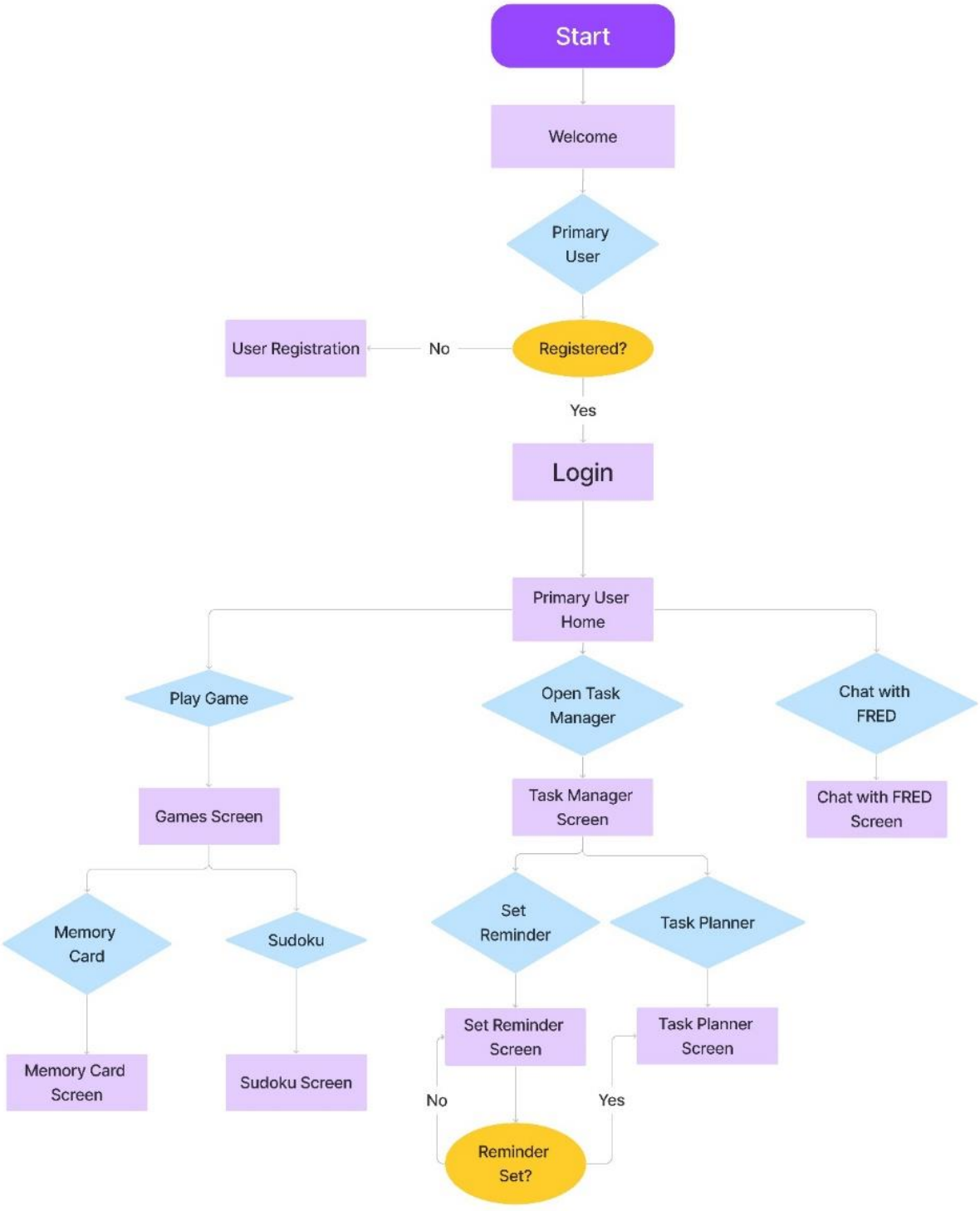

Figure 2: PWD High-Level Architecture

1.3 Caregiver Home Screen

Figure 3 shows the home screen that caregivers will see once they open the FRED app. The greeting was added to give users the feel of personalization while they are on the app. The main features to take note of for this side of the app are represented by the five tabs on the taskbar at the bottom of the screen: the home screen, the courses page, the loved one's page, the community page, and the self-care page. For convenience, the user's schedule, and ability to add reminders is highlighted in the top half of the home screen. Additionally, the FRED chatbot is added at the bottom of the screen to answer any questions users may have. The courses page will have courses and information about ADRD and how to care for someone with ADRD. The loved one's page will highlight important information about the caregiver's loved one, such as their location, their activity levels, and a notes page available to all caregivers. The community page will provide users with access to local resources, such as local caregiver support groups and events, and the ability to connect with caregivers in their area. Finally, the self-care page will allow users to take care of themselves using features like guided meditation, journaling, self-care reminders, and inspirational quotes.

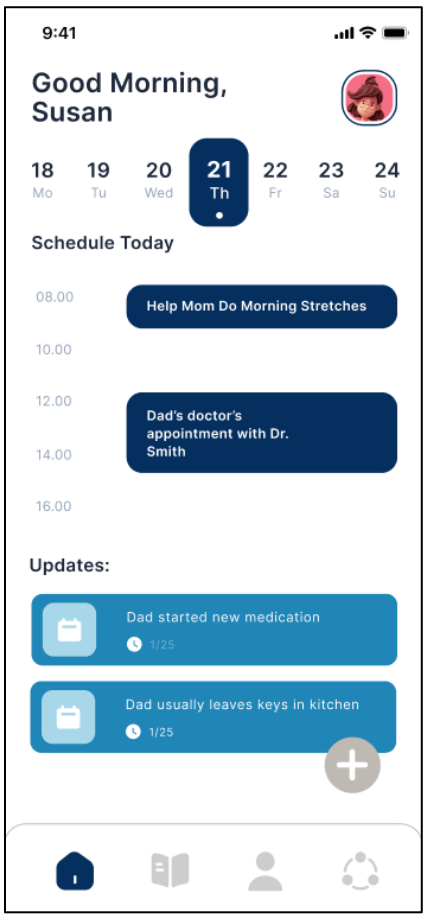

Figure 3: Caregiver Home Screen

1.4 High-Level Architecture of Caregiver

Figure 4 depicts the high-level architecture of the Caregiver side of the app through a user flow diagram. This diagram demonstrates how users will navigate through the app. Light purple rectangles represent the different screens of the app, while blue diamonds represent actions taken by the user, and finally, orange ovals represent questions that need to be answered to determine the user's path through the app.

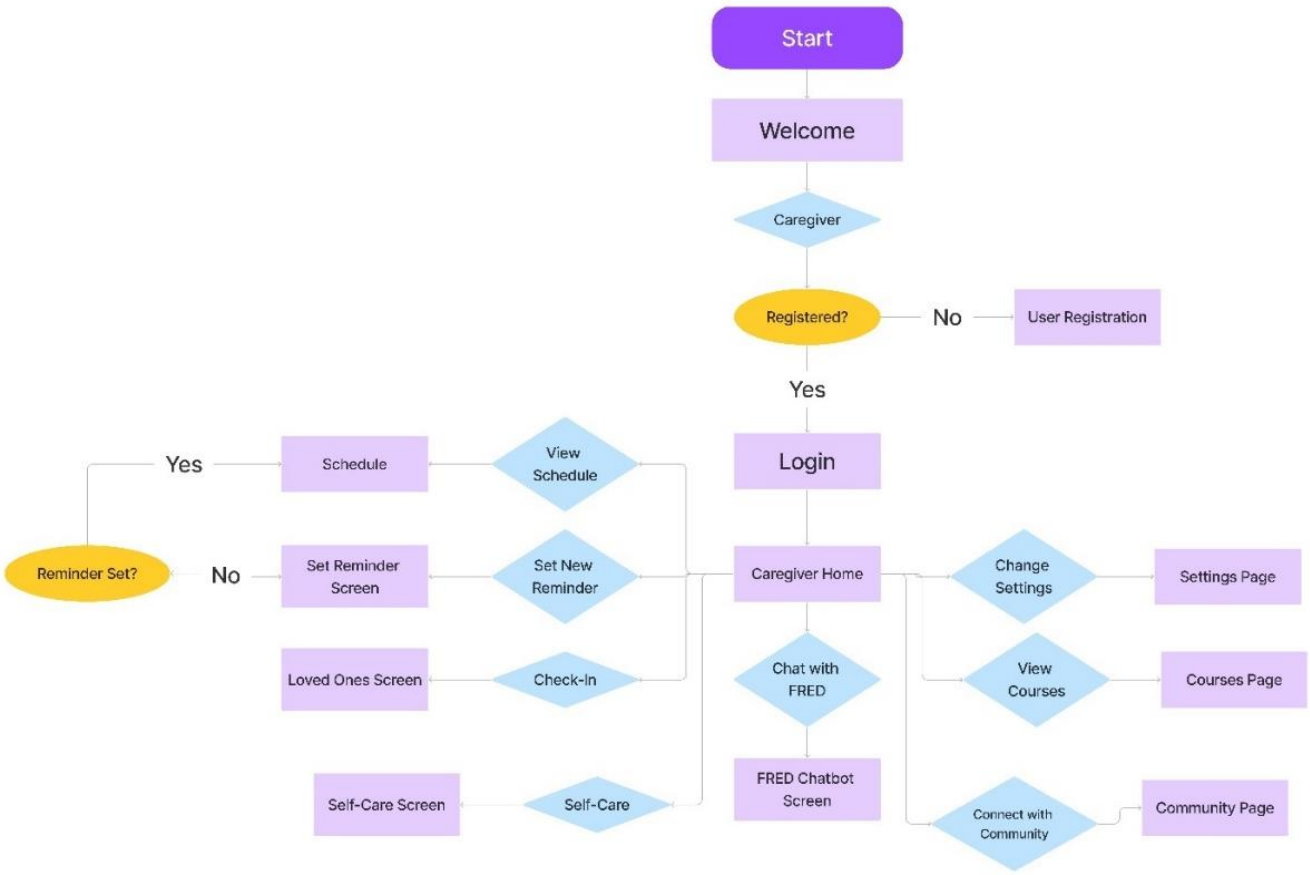

Figure 4: Caregiver High-Level Architecture

2. Results Summary

This section will include the resulting product the team has developed over the year. This includes the prototype system and process of prototype development for the PWD side of the application and the outline of the caregiver side of the application. Due to the PWD application being the only coded software for the final product, the PWD side is represented in the specifications and results for testing. The following will summarize all the results the team has acquired from the physical system, planned systems, and testing.

2.1 **Prototype System – PWD UI/UX**

The app was programmed in Flutter with a two-person development team. The UI was designed in Figma, and the app was modeled from the markup. The FRED application is divided into several pages that serve as access points to its essential features and sources of information for primary users. The components of these pages are described in the section below with details on the features included in the application as well. This is an overview of the information for the prototype of the PWD side with full details on the product in Volume 2.

2.1.1 **Navigation Bar**

All the FRED app's pages have a navigation bar, which is intended to make it simple for users to move between the program's different features and is displayed in Figure 5. This navigation feature was created to offer users a consistent, simplified way to browse the FRED app, enabling them to easily access different sections of the app and back out of features.

Figure 5: Navigation Bar Prototype

A simple back arrow on the left side of the bar directs the user to the FRED application page they were previously on. In Android versions of the application, this button will have the same functionality as the back arrow. Users can use the voice chat functionality with the FRED conversational agent powered by GPT-3.5 and Whisper by clicking the FRED icon in the center of the navigation bar. The FRED app will begin capturing user audio input as soon as the user pushes the button. The Whisper model from OpenAI will analyze this audio and turn it into a text transcript. After that, this will be forwarded to the dedicated FRED AI agent, which will react suitably per the user's input. The home button, located on the far right side of the navigation bar, when clicked, takes the user back to the FRED app's main page.

2.1.2 **Home Page**

The home page, shown in Figure 6, serves as a starting point that allows access to every feature in the FRED app. With the help of this hub, users may access every function of the FRED on a single, unified page. The tools that offer direct support to the user, including the task of the day display and emergency call feature, are always available on the website so that users can access them immediately when needed. Meanwhile, the central carousel, which will allow for straightforward navigation, is designated for the app's engaging elements, which the user would like to take part in.

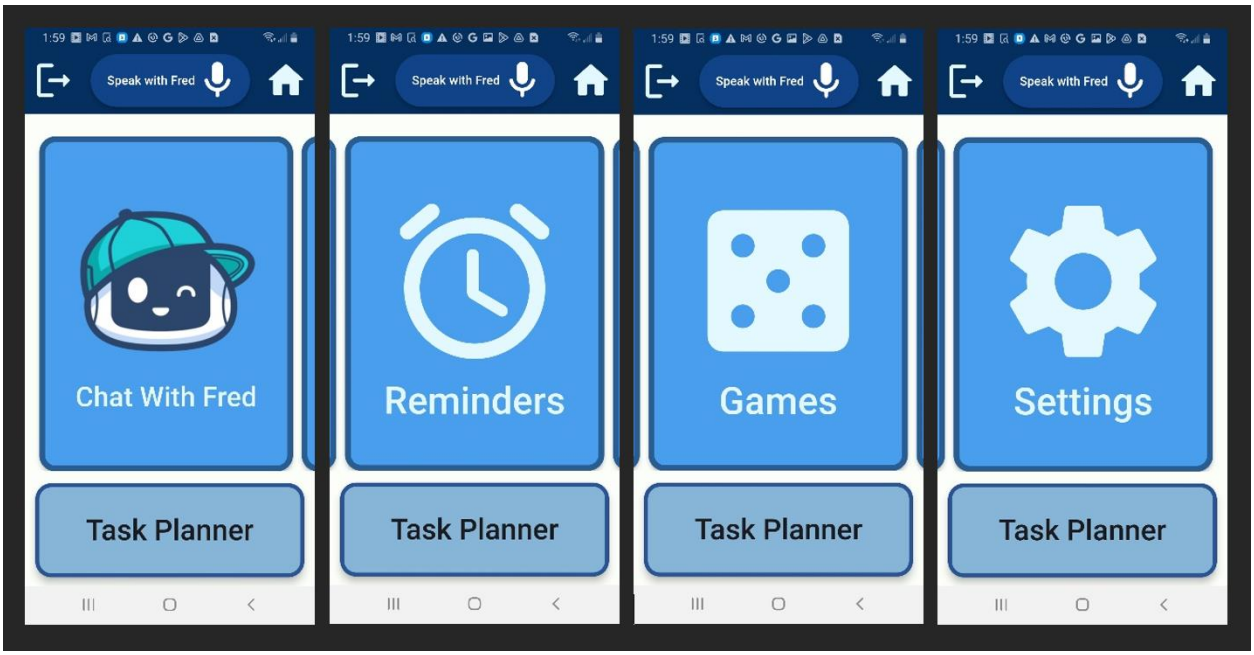

Figure 6: Home Page Prototype

In the center of the screen, the central carousel of all the app’s features is included to allow easy access to all the different features of the app. The task planner feature appears at the bottom of the screen and will give the users access to the calendar feature of the app where they can view and manage all the reminders set.

2.1.3 **AI Chatbot**

In the AI chatbot feature of the app, the user will be able to have a fun and lighthearted conversation with the FRED AI persona powered by Open AI’s ChatGPT 3.5 model. This chatbot is specifically designed through role assignment to be cognizant of issues that people living with dementia may face and actively tries to make conversation with the user when not being queried for help. The page showcased in Figure 7 was designed to make conversation with the chatbot as simple and as straightforward as possible. The user can interact with the feature using the text box which expands

into a keyboard like normal texting on a phone. Users may also use the speech-to-text feature to talk to Fred directly on this page.

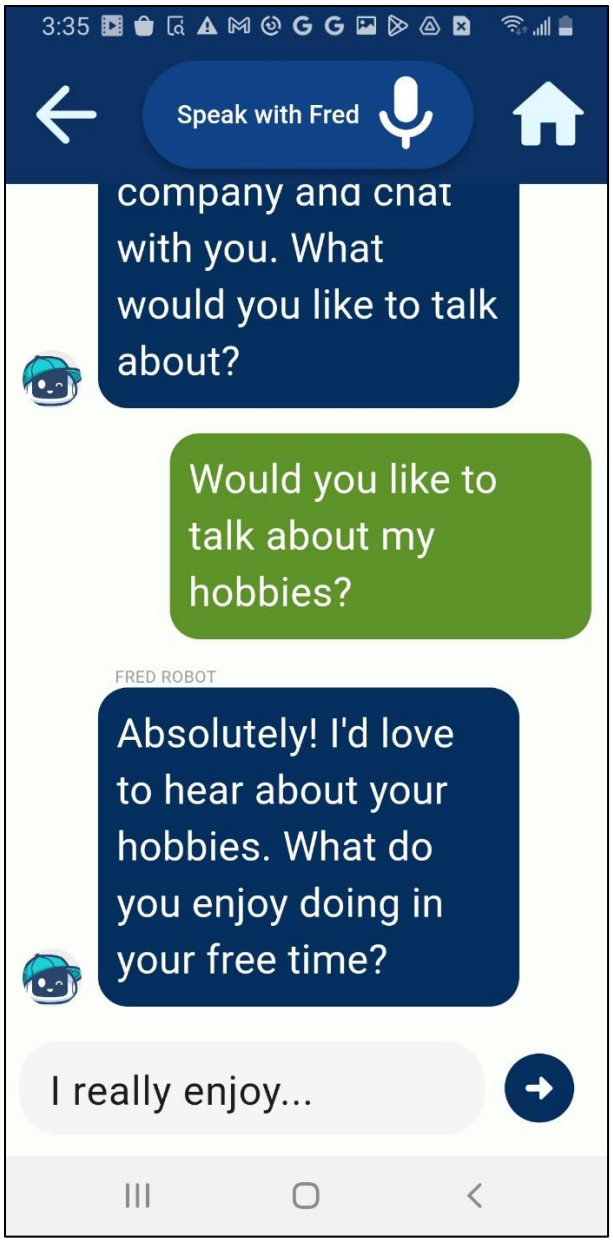

Figure 7: AI Chatbot Prototype

2.1.4 **Reminders**

The user can navigate to the reminders feature in the app to select whether they would like to set or view their reminders. If they select set reminders, they will be brought to the page displayed in Figure 8 where they can set their reminders for themselves.

Figure 8: Set Reminders Page

On this page, the user can set the name of the reminder which will be the main way they will be able to identify the reminder as it is displayed in the task planner. The user can also set the reminder classification on the page, which will invoke different backend API calls to give them specialized reminders via text, call, email, or push notification based on their preferences. After that, the user

can use the enlarged buttons to adjust the date they would wish to set the reminder and then hit the set reminder button.

2.1.5 **Task Planner**

The user can navigate to the task planner feature via one of two pathways. Selecting the task display widget at the bottom of the home page will navigate the user directly to the task planner page. Navigating through the reminders button on the home page and selecting the button labeled “Task Planner” will also bring the user to the task planner page demonstrated in Figure 9.

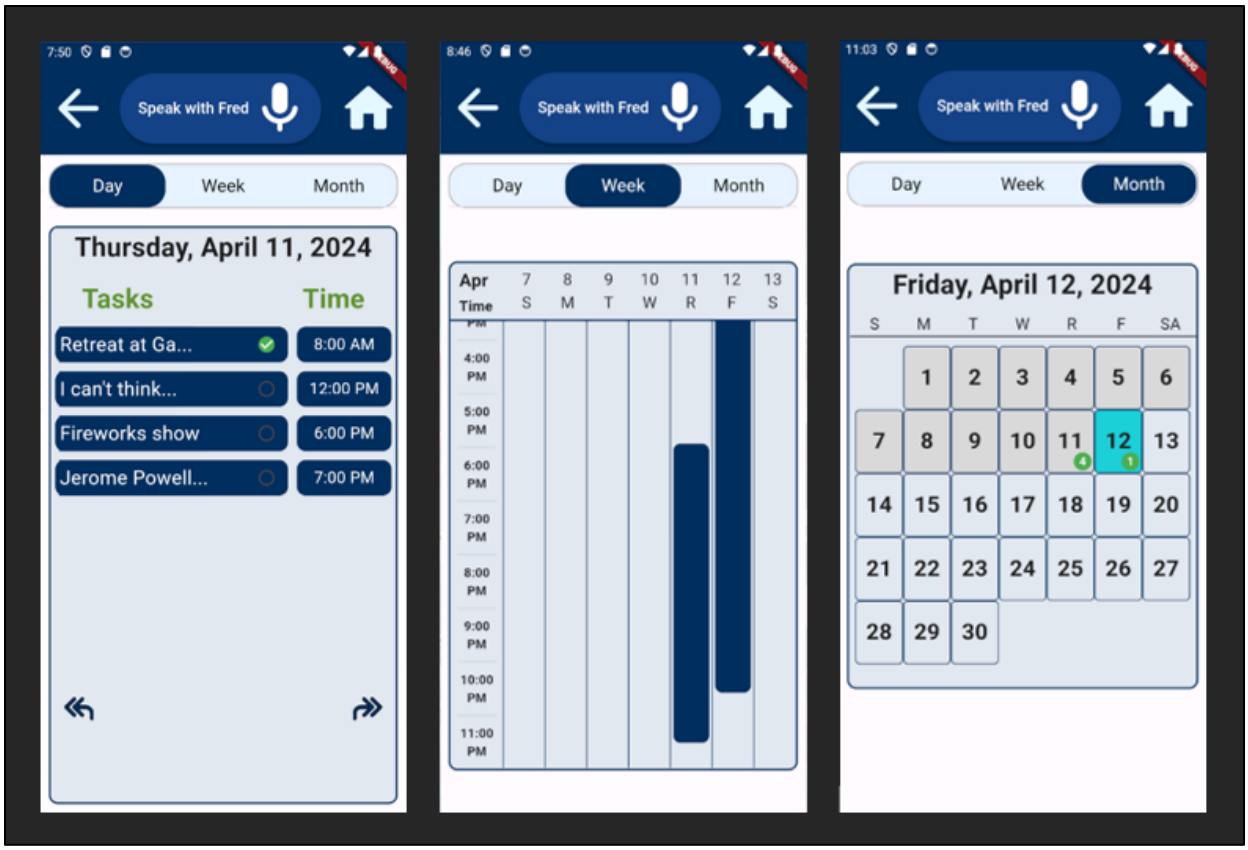

Figure 9: Task Planner Page

In the task planner feature, users can view the reminders they have set by pulling the set reminders from the Firebase. The users can view their data in three different views the daily view, the weekly view, and the monthly view. In the daily view, users can view the tasks they have for the current day. They can also mark the task as completed or click on the main body of a task to see an expanded view where they can see additional details of the view. The weekly view enables users to see their tasks in an organized view where they can see blocks of time throughout the week

when they have set tasks. The monthly view shows a calendar month with dots for each day that demonstrate the different tasks planned out for a given day of the selected month.

2.1.6 **Memory Card Game**

Selecting the games feature from the home screen enables users to play the memory card game programmed into the app displayed in Figure 10. This feature was programmed to engage users and allow them to complete the task to the best of their abilities with the hopes of providing cognitive stimulation which may be beneficial to slowing down cognitive decline.

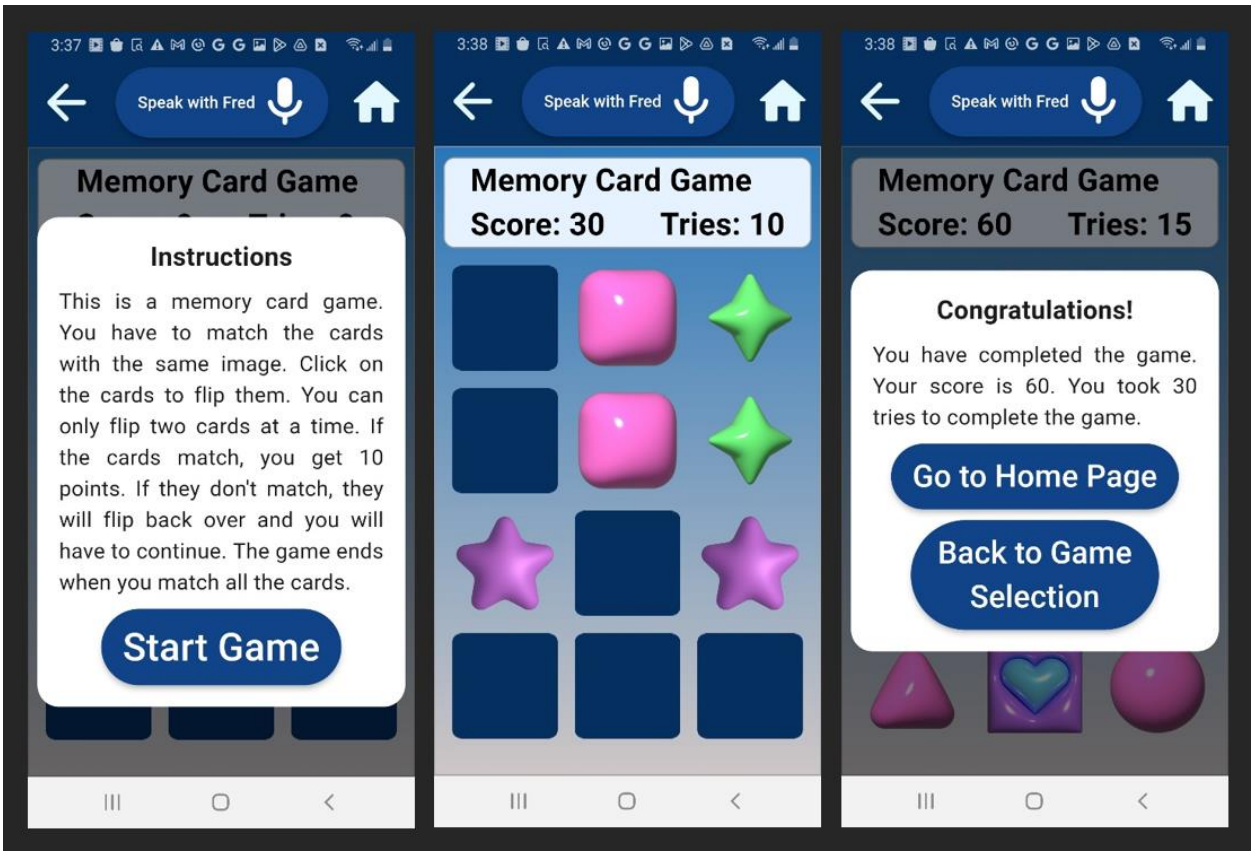

Figure 10: Memory Card Game Page

The memory card game will start by showing the user all the randomly assorted tiles on the screen face up for five seconds. After five seconds, the tiles will flip upside down and the user will try to match them. When the user makes a successful match, the FRED avatar will congratulate them, and the tiles will disappear from the screen. When the user makes an unsuccessful match of two tiles, the FRED avatar will notify them that the match was incorrect, and the tiles will be flipped back down until they are selected again. Once all the tiles have been matched, the completion screen will be displayed where the user can view their FRED avatar congratulating them and a trophy to reward them for their hard work. The button labeled “Go to Home Page” will navigate

the user to the home page of the app, and the button labeled “Back to Game Selection” will navigate the user to the game selection page where the user can either choose to play again or start a game of Sudoku.

2.1.7 **Sudoku Game**

Selecting the games feature from the home screen enables users to play the sudoku game programmed into the app displayed in Figure 11. This feature was designed to provide users with an endless variety of sudoku puzzles to solve to keep them cognitively engaged.

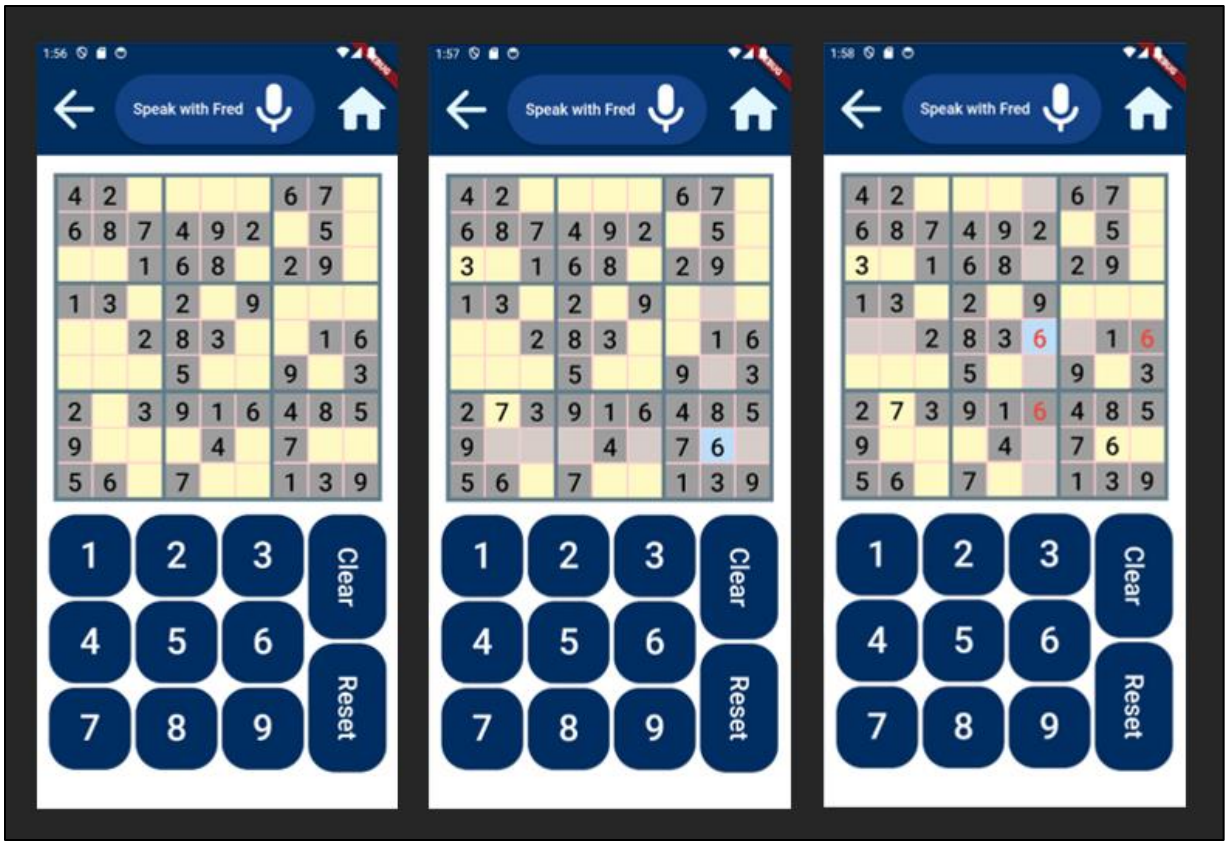

Figure 11: Sudoku Game page

The gameboard was designed in such a way as to take maximum advantage of the dimensions of a phone screen. The board’s size is prioritized, and the keypad to interact with the board. The process of playing displayed is as follows: the user can select a square on the empty board by tapping it, once the square in Figure 11 selected, the horizontal and vertical columns of the board are highlighted to visually aid the user in solving the square, and once the user has chosen the number, they wish to populate the square with, they can select the corresponding number on the keypad below. The square will fill in with a black number if the user’s choice does not conflict

with the board, and the square will fill with a red number if the choice does conflict with the board and the other conflicting numbers will also be highlighted red. The board will turn green once the user fills all the squares with no conflicting spaces. The user can clear the board by selecting the “clear” button, and the user can change the entire puzzle to a completely new board by selecting the “reset” button.

2.1.8 **Settings**

Selecting the settings feature from the home screen allows the user to adjust their account settings displayed in Figure 12. This feature was designs so users could edit all of their existing account settings in one place.

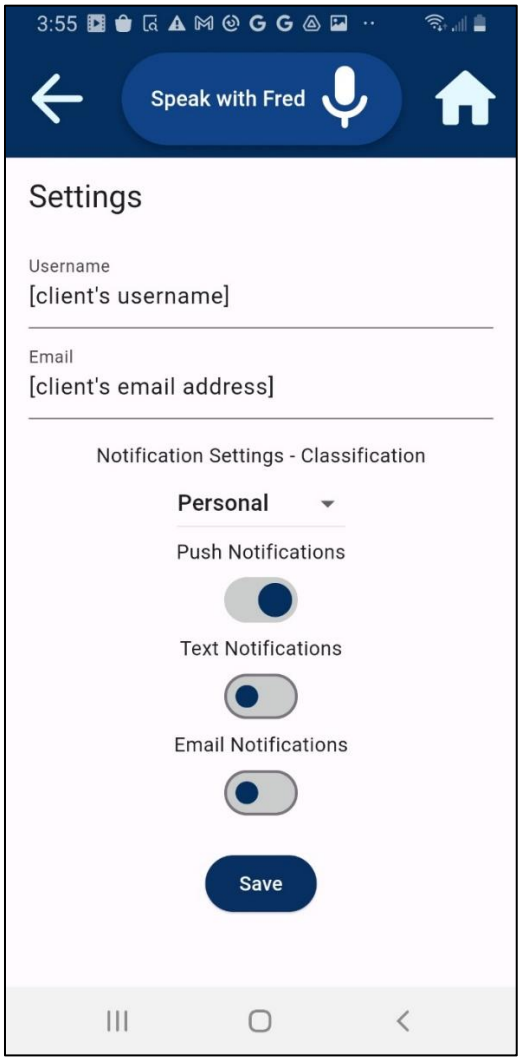

Figure 12: Settings Page

The settings page was set up where the user’s settings for their account could be accessed in one

place. The user's username, which is known by the chatbot to identify the user, can be changed here to whatever preferred name the user would like to use. The email address associated with the account can also be changed here. This is useful in case the user would like to switch the account over to a new email address for any personal reasons. Additionally, the user can select the classification settings for their reminders feature here. The dropdown menu allows the user to select one of the three native classifications for a reminder: "Personal", "Appointment", and "Prescription". The user can then use the switches for each reminder to determine which notification methods will be used for the specified classification of reminder. Once all the desired changes to settings have been made, the user just needs to press the save button at the bottom of the page to keep their changes. For this prototype version, the switches for text and email notifications do not functionally work for enabling the specified notification types as a backend server is required for the notifications to be delivered via text or email. This will be changed when a backend server for the app is set up.

2.2 **Prototype: Caregiver UI/UX**

To improve the viability of the FRED app as a product that can be commercialized, the team generated a solution in the form of the caregiver application that can be integrated into the PWD application in the future. The caregiver application helps the project meet the goal of easing the burden on caregivers by providing information, PWD updates, self-care tips, and community connections. These features were developed from caregiver input based on feedback from the team's attendance at caregiver meetings. Here are the details on components of this side of the app and samples of the user interface and user experience that was developed through Figma.

2.2.1 **Courses**

The *Courses* feature on the caregiver side of the app in Figure 13 offers a comprehensive resource hub, providing access to a range of informative articles and courses aimed at enhancing the quality of care for individuals with dementia. Caregivers can explore various courses covering essential topics such as different types of care, transitioning between care stages, and engaging activities to keep the PWD occupied and stimulated. They can also access general knowledge in scientific articles chosen from reputable sources. Additionally, for caregivers seeking more specialized knowledge, we offer technical courses available behind a paywall, ensuring access to in-depth information and expertise. To further streamline the learning process, an AI chatbot is integrated into the platform, assisting caregivers in finding suitable courses based on their inquiries and providing valuable guidance along their caregiving journey. With the *Courses* feature, FRED empowers caregivers with the knowledge and resources necessary to provide optimal care and support for their loved ones with dementia.

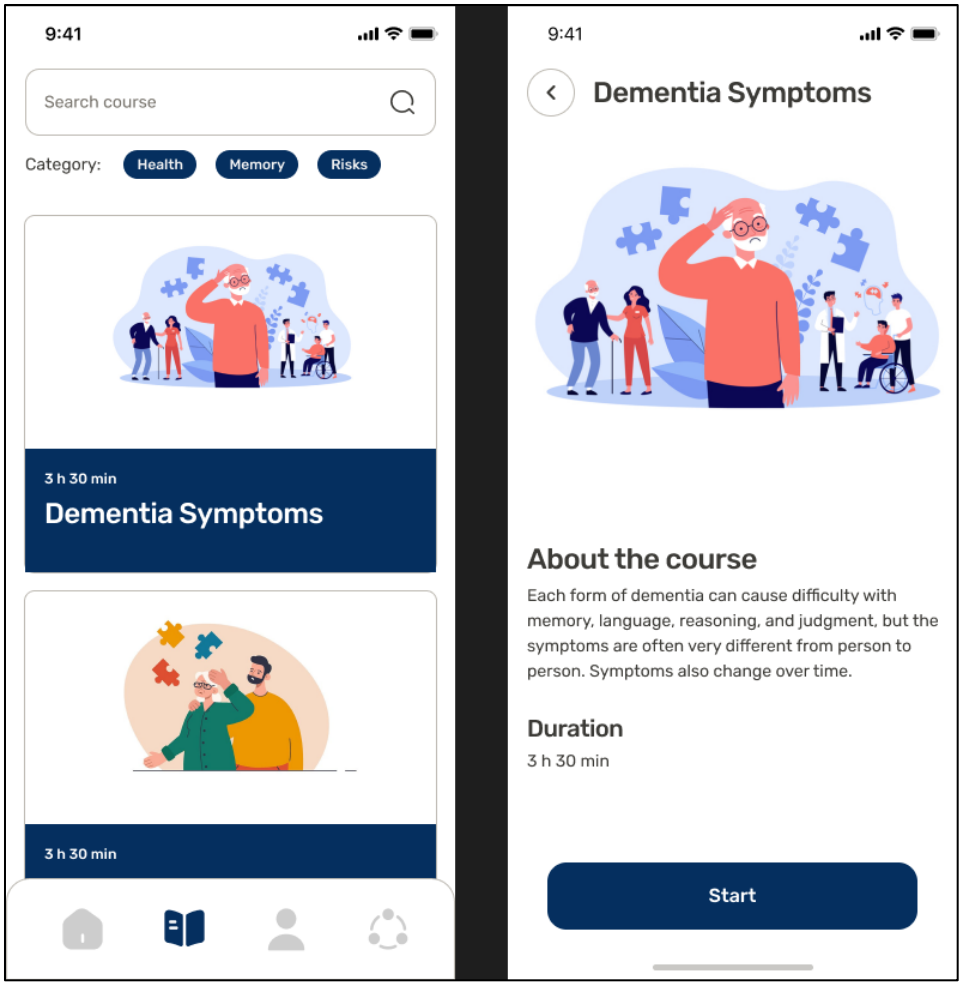

Figure 13: Courses Page for Caregiver UI/UX

2.2.2 **Loved Ones**

The *Loved Ones* feature in the app provides caregivers with vital tools to monitor and support their loved ones with dementia. Offering real-time insights into their loved one's well-being, caregivers can track their current location and receive notifications if they travel beyond predefined boundaries, ensuring their safety. As shown in Figure 14, the feature also includes activity tracking, displaying the number of steps taken, and seamlessly syncing with Apple Watch for users who utilize this device. Caregivers can manage tasks and reminders, keep track of completed activities such as eating and medication intake, and promote adherence to care plans. A key component of the *Loved Ones* feature is the medical and activity notes section, facilitating communication among different caregivers by providing a centralized platform to document important information, including medication logs, charting data, and journal entries to monitor their loved one's health and progress over time. By consolidating these essential features into one accessible interface,

caregivers can effectively coordinate care and ensure the well-being of their loved ones with dementia.

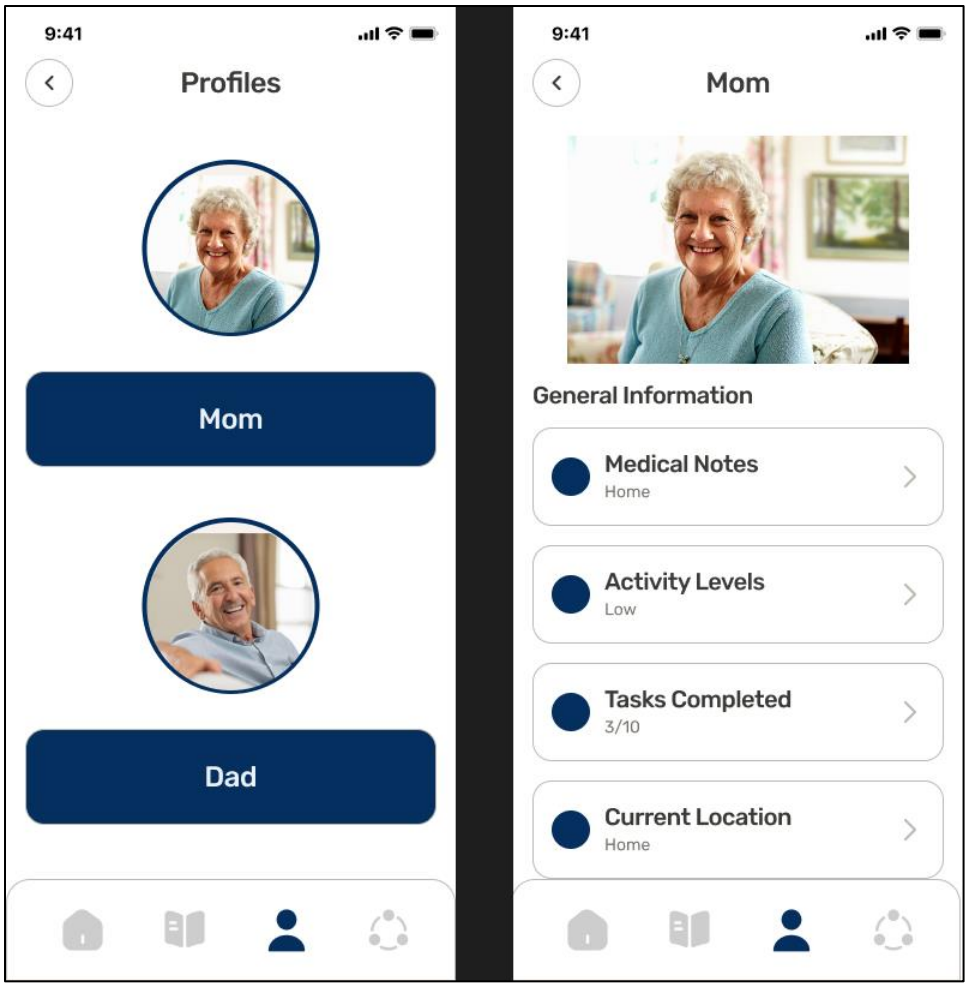

Figure 14: Loved Ones Page for Caregiver UI/UX

2.2.3 **Community**

The *Community* feature serves as a vibrant hub for caregivers to connect, engage, and access valuable local resources. Through interactive maps, caregivers can easily locate nearby support services, including medical facilities, support groups, and dementia-friendly establishments, enhancing their ability to navigate their local community with confidence. The integrated events calendar keeps caregivers informed about upcoming workshops, seminars, and social gatherings tailored to their interests and needs. Furthermore, the discussion boards provide a platform for caregivers to share experiences, exchange advice, and offer support to one another, fostering a

sense of community and solidarity. By leveraging technology to bridge geographical gaps, FRED's *Community* feature empowers caregivers to forge meaningful connections, access essential resources, and find solace in the shared journey of caring for loved ones with dementia.

2.2.4 **Self-Care**

Finally, the *Self-Care* feature is designed to prioritize the well-being of caregivers, recognizing the importance of self-care in maintaining resilience and balance. Personal reminders prompt caregivers to engage in activities that promote physical and mental health, such as taking breaks and going for walks, fostering moments of rejuvenation amidst the demands of caregiving. Guided meditation sessions offer a tranquil retreat, providing caregivers with tools to manage stress and cultivate mindfulness. The journaling feature provides a reflective space for caregivers to process emotions, track their experiences, and celebrate personal achievements, fostering self-awareness and growth. Inspirational quotes and general tips serve as gentle reminders to nurture social connections, seek support when needed, and embrace moments of joy and gratitude. By integrating these self-care tools into our app, FRED empowers caregivers to prioritize their own well-being, ensuring they have the strength and resilience to continue providing compassionate care to their loved ones with dementia.

2.3 **Product Specifications**

Product specifications are the metrics used to determine how the team will address the requirements of the stakeholders for the project. These specifications are involved in acceptance testing measuring specific aspects of the progression of the app toward meeting requirements. Table 1 lists the specifications of the FRED application along with their given number, associated metric, target for the metric, and the direction of progress. For example, the team has a specification for loading time and lag time (S05) with a metric of seconds. The target is to have a time under 1 second which will put the direction as down, indicating the lower the value the closer the specification is to being met. More details on each specification are included in Volume 2 along with details of the acceptance tests included in Volume 3.

Table 1: Product Specifications included in Acceptance Testing

No.	Specification	Metric	Target	Direction
S01	Task Completion Rate	% Completed Tasks	>90% completed tasks	up
S02	User feedback	Average rating	>80% avg rating	up
S03	Daily time spent on app	Time in hours	>2 hours daily	up
S04	Stress testing	Response accuracy	Progressively higher use	up
S05	Loading/lag time	Time	<1 second load time	down
S06	Vulnerability	Count Vulnerabilities	Less than 3 Potential Vulnerabilities	down
S07	Advertising	Connections	Increase connections to local ADRD centers	up
S08	Comparable Price	Price of App	Low cost than comparable app	down
S09	Cognitive Game Score	Score on Game	70-90% score avg	stable
S10	Mood Improvement	1-5 survey	.9+ Avg improved mood	up
S11	Typeface	% Correct	90% correct	up
S12	Color Contrast	Pass/Fail	All Pass	up

The technical performance measures help the team gauge the progress of the project towards meeting the stakeholder requirements. Meeting these goals would most likely mean success in the project while also showing primary deficiencies in development and testing. Due to the nature of the project and the slight changes in the scope of the project. The team developed a new concept from scratch and the goals of the project have reflected the steps that have seemed necessary at the time. Table 2 shows the technical performance measures that will be listed at the end of the semester along with their target metric and the progress of the TPM over the year.

Table 2: Technical Performance Measures

TPM	Target	PDR	SLDR	QRB1	QRB2	FDR
S02 User Feedback	>80% rating form surveys	n/a	n/a	n/a	<80%	70%
S05 Loading/Lag Time	<1 second load time for pages	n/a	<3 seconds	<1 second	< 1 second	<1 second
S11 Typeface	>90% accuracy	0%	0%	40%	40%	100%
S12 Color Contrast	Pass WCAG tests	pass	pass	pass	pass	pass
conditions	Red = unmet	Yellow = in trouble	Green = met			

2.4 **Acceptance Test Results**

To determine how the final prototype meets the product specifications, the NOVI team performed the acceptance tests listed in Table 3, which include the specifications, test, target, and result. Despite not meeting all targets for the acceptance testing, the team has succeeded in determining the viability of the product designed to meet the expectations of the sponsor. The final product does fail in many aspects related to the stakeholders of the users and caregivers, but without finishing a distributable product these failures are not impactful for further development. Some specifications required multiple tests or had multiple aspects that could not be performed in a single test due to changes in the scope and additional requirements needed to fully accommodate the previously set specifications.

Table 3: Acceptance tests performed to determine adherence to product specifications attainable during the ISD course.

Product Specification	Acceptance Test	Target	Result
S02 User Feedback: caregiver feedback	Surveying caregivers on UI elements.	>80% average rating	Pass - Conditional
S02 User Feedback: demo feedback	Surveying UT affiliated students and staff on prototype experience.	>80% average rating	Fail
S02 User Feedback: PWD user feedback	Surveying PWDs on their experience with complete MVP application	>80% average rating	Fail - Conditional
S05 Loading time: App Connectivity	Ensuring the application does not crash on launch or when accessing features	Use all features in the app in a randomly generated order 5 times without restarting the application.	Pass
S05 Loading/Lag Time: Loading page time	App loading time and connectivity to login page through Firebase	< 3 seconds	Pass
S05 Loading time: App Connectivity	App loading of internal memory timed and below particular threshold	< 1 second	Pass
S05 Loading time: ChatGPT and Open AI Connectivity	API call to Open AI's Whisper and ChatGPT models for speech to text load time	< 1 second	Pass
S11 Typeface	Show positive results from survey data on typeface	>90% accuracy	Fail
S12 Color contrast	Use WebAIM contrast checker on app's adjacent colors	Pass WCAG AA and WCAG AAA standards	Pass - Conditional

2.5 **Commercialization Plan Summary**

The NOVI team made strategic additions to the FRED app by introducing a caregiver side and creating two potential revenue streams to support the app's business model. This move allows for a free base version of the FRED app for users, aligning with the mission of providing access without monetary barriers for people with dementia and their caregivers. The two potential revenue streams include advertising on the community page and research page. The freemium model was determined as the best monetization model for the FRED app. The estimated annual maintenance costs are around $85,000 based on industry standards. The NOVI team emphasizes setting aside funds for ongoing maintenance to ensure app quality and user satisfaction, especially as the user

base grows. Overall, these strategies aim to sustainably support the FRED app's development and its mission of providing a *product with a purpose*.

2.6 **SBIR Summary**

The Small Business Innovation Research (SBIR) program is a competitive funding initiative in the United States that encourages small businesses to engage in federal research and development with the potential for commercialization. It provides grants to support innovative projects across various sectors, including technology, healthcare, and defense. The goal of the SBIR proposal for the FRED project is to acquire funding for the commercialization of the app. The revenue that is generated from the app will then be used to fund Dr. Zhao's research lab. NOVI will be completing specific sections of the SBIR which include:

- Research Plan
- SBIR/STTR Information
- Commercialization Plan

Once Dr. Zhao creates a business, he can use these sections to fill out forms found on the National Institute of Health (NIH) website. The completed sections of the SBIR are reflected in Volume 4.

3. **Conclusion**

Throughout the project, NOVI diligently endeavored to fulfill Dr. Zhao's vision of an app inspired by FRED robots to support individuals with ADRD and their caregivers. A prototype was successfully developed using Flutter, showcasing key functionalities and features both desired by Dr. Zhao and included based on research done by NOVI. Additionally, in response to insights gained from engaging with a caregiver support group, the team recognized the importance of further supporting caregivers and subsequently designed a UI/UX layout in Figma to address their needs. However, it is acknowledged that more extensive user testing, particularly concerning accessibility and broader feedback collection, could have been conducted to ensure comprehensive user satisfaction. While the prototype is complete, the unresolved issue of limited testing poses a potential risk.

Moving forward, it is recommended to conduct additional user testing to refine the app's accessibility and usability, incorporate feedback from diverse user groups, and allocate resources for ongoing maintenance to ensure the app remains effective and relevant in enhancing the lives of individuals with ADRD and their caregivers. Additionally, considering the potential of the app, Dr. Zhao should establish a company over the summer so that he can submit an SBIR proposal to secure funding for further development promptly. This funding can support a pilot launch of the app to acquire an initial user base. Then once a user base has been established, monetizing the app through the caregiver side can lead to the creation of a successful and ethical business model.

3.1 Customer Needs and Product Features

The following section outlines the comprehensive roadmap for the future development of the FRED app based on the progress NOVI has made thus far. These next steps encompass two primary aspects: development and commercialization. For development, the focus will be on enhancing the app's functionality by adding a backend server and incorporating the caregiver side into the app. For commercialization, NOVI recommends that Dr. Zhao create a company so that he can apply for SBIR funding, and then use this funding to fully code the app. Once the app has been completed, Dr. Zhao should initiate a beta pilot program to gather feedback before ultimately monetizing the app through caregiver features. These steps collectively aim to propel the project towards its goal of creating a successful and impactful solution for individuals with ADRD and their caregivers, while also laying the groundwork for sustainable business growth.

3.1.1 Next Steps for Development

Establishing a backend server for the FRED app at its production level is a necessary step toward ensuring the seamless operation and robust security of the application. This infrastructure is instrumental in safeguarding sensitive data, particularly API keys required for backend API interactions with pivotal services such as OpenAI, Twilio, and Nylas. By centralizing these keys within a secure server environment, rather than embedding them within the client-side application, NOVI significantly mitigates the risk of unauthorized access and potential data breaches. This security measure is crucial, not only for protecting the integrity of the app's functionality but also for maintaining the trust of its users.

The development of a backend server would also play a crucial role in the management of the app's reminder features. It enables the execution of API calls to schedule and trigger reminders independently of the client application's running state. This architectural choice ensures that reminders are reliably delivered to users, regardless of the current state of their device or the app itself. Such a design is particularly beneficial in a healthcare context, where timely reminders can be critical for medication adherence and the completion of daily tasks, thereby directly contributing to the well-being of individuals with Alzheimer's Disease and Related Dementia (ADRD).

Additionally, a backend server facilitates more refined and secure handling of user data. It allows for the implementation of advanced security protocols and data encryption, which are essential for complying with healthcare regulations and ensuring user privacy. By processing and storing sensitive information on the server side, the app can minimize the volume of data transmitted between the client and server, thereby reducing exposure to potential vulnerabilities. This approach not only enhances the app's overall security posture but also supports scalable and efficient data management practices, enabling the app to better serve a growing user base without compromising performance or user experience.

3.1.2 Next Steps for Commercialization

An MVP with both the person with dementia side and caregiver side implemented needs to be launched to a select group of users through a beta pilot program to gain 1,000 users. This program aims to gather feedback from early adopters, refine the app's features, and ensure its usability and effectiveness in addressing the needs of people with dementia and their caregivers.

3.1.3 Next Steps for SBIR

The two main steps to submitting an SBIR to the NIH are first, registering a company, and second, filling out an SBIR application tailored to a specific request for proposal on the National Institute of Health (NIH). Table 4 shows the information NOVI completed and the forms Dr. Zhao will need to fill out before submitting the SBIR. A complete summary of the information needed in each form is found in Table 5 in Appendix A. The forms that are not complete pertain to information about the company Dr. Zhao will create, such as facilities, employees, and equipment. NOVI has completed the main sections of the SBIR, including the Research Plan and the Commercialization Plan, which describe the FRED app in detail and the overarching business case (please see Volume 4 for more information).

Before applying for funding, Dr. Zhao must first create a company and complete multiple registrations for that company to be eligible for SBIR funding. These include the System for Award Management (SAM), the eRA Commons, Grants.gov, and the Small Business Administration (SBA). SAM is required to do business with the U.S. government, and upon registering they will issue a unique identifier that can be used with other federal systems. Furthermore, the eRA commons are required to do business with NIH and some HHS agencies. The company needs to be registered with Grants.gov as this is required to submit a grant application through the federal-wide grant portal. SBA is needed to participate in SBIR and STTR federal funding programs. It is important to register the company as soon as possible as it can take 6 weeks or more to complete the registration process. Once the company is registered, Dr. Zhao can apply for funding.

Table 4: SBIR Forms and Completion Level

Form Type	**Completed/To Be Completed By**
Phase I: SF 424 R&R Form	Dr. Zhao
Phase I: Project/Performance Site Locations	Dr. Zhao
Phase I: R&R Senior/Key Person Profile Form	Dr. Zhao
Phase I: R&R Budget Form	Dr. Zhao
Phase I: PHS 398 Research Plan Form	Team NOVI
Phase I: SBIR/STTR Information Form	Dr. Zhao
Phase I: PHS Human Subjects and Clinical Trials Information	Dr. Zhao
Phase I: PHS Assignment Request Form	Dr. Zhao
Phase II: Commercialization Plan	Team NOVI

3.2 Summary of Unresolved Issues and Status of the Prototype

The prototype developed by NOVI is reaching a point of development where it is almost ready for release as a minimally viable product. There are a few issues with the prototype that should be handled before the official release of the application. Several markable improvements could and should be made before the product's official release.

The codebase of the application needs to be cleaned up to ensure that the application runs and compiles as efficiently as possible. The application also needs to be loaded onto many different Android and iOS devices to ensure that all UI elements resize accordingly to the different screen ratios. Additionally, the dependencies and APK build will need to be updated to the latest version before release to ensure the maximum longevity of the app before the codebase needs to be updated again. Due to the scope of the project, Android was the best method of production for the app, but Flutter should enable future developers to easily implement iOS devices.

There are major concerns about the security of the app moving forward with a vulnerable population using OpenAI-based software. There are various ways to abuse this and exploit issues with security and privacy. Future work should find privacy concerns to be a top priority. There may also be considerations to eliminate some AI features such as the chatbot to eliminate risks. The AI is planned to be further integrated with the app for navigational purposes as well as in app suggestions, but these tasks may be able to be performed with different methods that would be safer for individuals to use.

3.3 **Recommendations**

The version of the app portrayed in these reports is meant to be the baseline product that should be improved on with future work. Based on current feedback, the NOVI team has recommendations regarding the direction the project should go moving forward.

First, the code base should be improved. NOVI focused on creating an MVP, and due to limited prior coding knowledge, the current code base is unorganized and not suitable for a marketable app. NOVI suggests either improving GitHub or moving to Jira. With that groundwork done, NOVI suggests that future developers focus on improving the current features of the FRED app and optimizing the UI/UX through more thorough user testing. Additionally, NOVI suggests that the development of the caregiver side of the app be fully developed and integrated into the PWD side.

The next recommendation is for development to put a larger focus on security as mentioned previously. Security will be essential while using AI in the app to keep users safe and provide a morally sound product. In other words, security tests should also be integrated to ensure the app is safe.

Recommendations regarding testing are included in the subsequent volumes of this report. As an overview, limitations on time and progress in development did not allow the team to perform all the tests designed. The most challenging part of testing was that care homes and groups were not responding or were unavailable. It is suggested to continue user testing to ensure the right features are incorporated (see Volume 3 for more information). Additionally, the affordability of the app needs to be tested with users to help increase the chances of success in the marketplace.

List of References

[1] “Dementia,” World Health Organization, https://www.who.int/news-room/fact-sheets/detail/dementia (accessed Apr. 15, 2024).

[2] “How to build a backend for a mobile app?,” Back4App Blog, https://blog.back4app.com/how-to-build-a-backend-for-a-mobile-app/#Custom_backend (accessed Apr. 15, 2024).

Appendix A. Detailed List of SBIR Forms

Table 5 shows the forms that need to be completed or submitted by Dr. Zhao. The table also exhibits a summary of the information that needs to be included in the forms.

Table 5: Detailed List of SBIR Forms

Form Type	**Summary of Content**	**Completed By/To Be Completed By**
SF 424 R&R Form	• Other project information form • Project summary/Abstract • Project Narrative • Bibliography • Facilities and other resources • Equipment • Other attachments	Dr. Zhao
Project/Performance Site Locations	• Primary location • Site location 1 • Additional locations	Dr. Zhao
R&R Senior/Key Person Profile Form	• Profile: Project Director/Principal Investigator • Instructions for Biographical Sketch • Profile - Senior/Key Person • Additional Key Person profiles	Dr. Zhao
R&R Budget Form	• Comprehensive budget	Dr. Zhao
PHS 398 Research Plan Form	• Introduction • Research Plan Section • Specific Aims Research Strategy • Significance • Innovation • Approach • Progress Report Publication List • Other Research Plan Section • Appendix	Team NOVI
SBIR/STTR Information Form	• Qualifying questions	Dr. Zhao

PHS Human Subjects and Clinical Trials Information	• Information on use of human subjects and clinical trial information	Dr. Zhao
PHS Assignment Request Form	• Request regarding assignment	Dr. Zhao
Phase II: Commercialization Plan	• Value of SBIR/STTR Project, Expected Outcomes, and Impact • Company • Market, Customer, and Competition • IP • Finance Plan • Production and Marketing Plan • Revenue Stream	Team NOVI

F.R.E.D.

Final Design Report Volume 2: Product and Process Documentation

April 29, 2024

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List of Terms and Abbreviations

AI	Artificial Intelligence. A field of computer science focused on creating systems and machines that can perform tasks typically requiring human intelligence, such as learning, problem-solving, and decision-making.
API	Application Programming Interface. A software intermediary that allows two applications to talk to each other and share data within and across organizations.
ADRD	Alzheimer's Disease and Related Dementias. The broad range of neurodegenerative diseases fall under this category.
ISD	Interdisciplinary Senior Design. An educational program at the University of Tennessee where students work with companies to develop industrial and commercial prototypes.
MVP	Minimal Viable Product. A version of a product with just enough features to be usable by early customers who can then provide feedback for future product development.
PWD	Person(s) with dementia. A term used to define people who are diagnosed with Alzheimer's or related dementia.
SBIR	Small Business Innovation Research. Programs to fund a diverse portfolio of startups and small businesses across technology areas and markets to stimulate technological innovation, meet Federal research and development needs, and increase commercialization to transition research and development into impact.
UX/UI	User Experience / User Interface. User experience relates to how a user feels whenever they interact with a product or service. User interface refers to the touchpoints a person uses to engage with a digital product.

1. Product and Process Documentation

The NOVI team has been tasked with developing a mobile application based on the previous FRED robot project. The two main goals of this application are enhancing the daily lives of persons with dementia (PWD) and easing the burden on caregivers of those persons with dementia. This report will detail the product that the team has developed over the two semesters of the Interdisciplinary Senior Design (ISD) class and define the processes involved in the application. Sections of this report will include a detailed summary of what features are included in the app and the application's structure.

1.1 Design Details

The design for the application began with hand-drawn layouts that were developed into designs on Figma. Figma is an online platform where developers can easily create mockups of UI for different applications before committing the time it would take to code the UI out. Figma is commonly used by graphic designers to show what digital content will look like. Figure 1 shows an example of the Figma page used during development. The same software was used to create the caregiver side of the application as well.

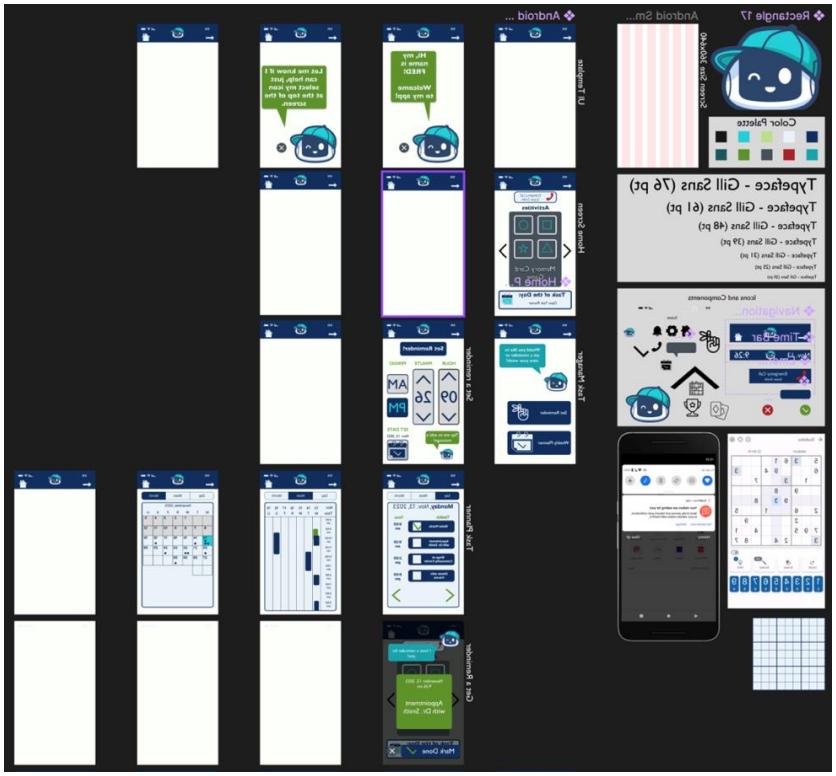

Figure 1: Figma design space for PWD app.

The colors of the application were an important decision in designing for accessibility. To select these the team did some research into color preferences for senior individuals and found that shades of blue were the most attractive. The team used a random color generator from coolors.co to find shades of blue to implement into the design. Green was selected to complement this along with white and a shade of grey for contrast. These colors were tested in acceptance testing to ensure that the contrasts were within accessibility guidelines. In the design, many icons had to be used from outside sources. This source was thenounproject.com. This website provides icons and components for graphic designers with respect to the creators. In the case the app was published, the creators of the design would be required to be referenced, which is done by purchasing a subscription to thenounproject.com or through references in the content they are used in. Figure 2 shows an example of these component icons used in the home bar.

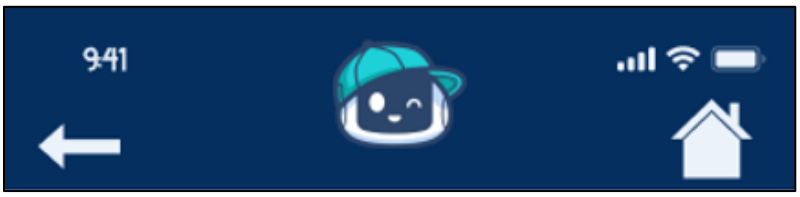

Figure 2: Home bar for the FRED application.

This home bar is a part of every page in the app, allowing consistent navigation for the user. Seen in the home bar is the FRED icon. The team came up with two mascots for the FRED design which will be mentioned in user surveys later in this report. Figure 3 shows the current FRED mascot that is used with the developed PWD app. This original mascot was generated with AI and chosen for its similarity to the original FRED robot.

Figure 3: Original FRED mascot for the PWD app.

For text in the app, the team wanted to take a consistent approach while also adhering to accessibility standards with text size and font. The team selected Gills Sans as the font type. This was advised by designers for the original FRED robot as it is considered a highly legible digital font. For consistency in the text, the team used typescale.com to generate a consistent ratio of point sizes for text of different sizes. Figure 4 shows an example of the type scale used during the design process. Text size was further updated in prototypes of the FRED app.

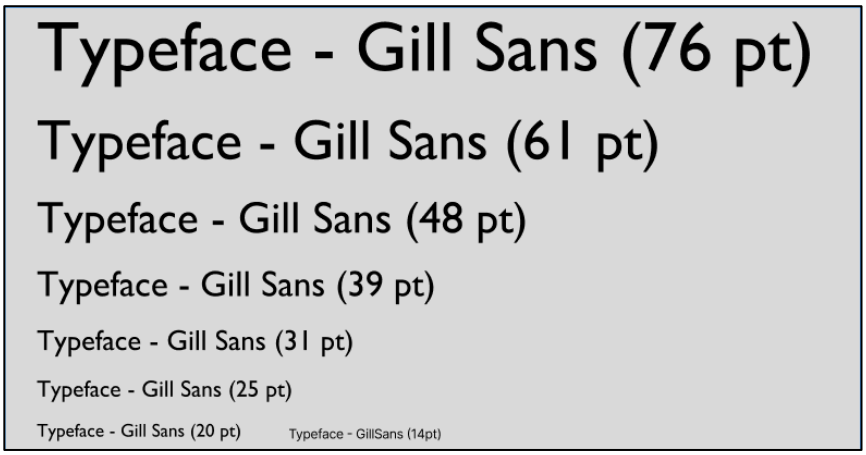

Figure 4: Type scale for the PWD app.

An aspect of the app for accessibility is the layout of components and buttons within the app. This can be demonstrated best in the home screen layout. The team decided a design with the features shown in a swipe layout would be the easiest way to navigate between features. Figure 5 shows the home screen from the final prototype. Users can scroll between features in this layout and have easy access to the task planner, which should be one of the most used features. The home screen from Figure 2 has been updated to include the AI chatbot and still includes home and back buttons. This layout is like the original FRED robot for a consistent approach to design and use.

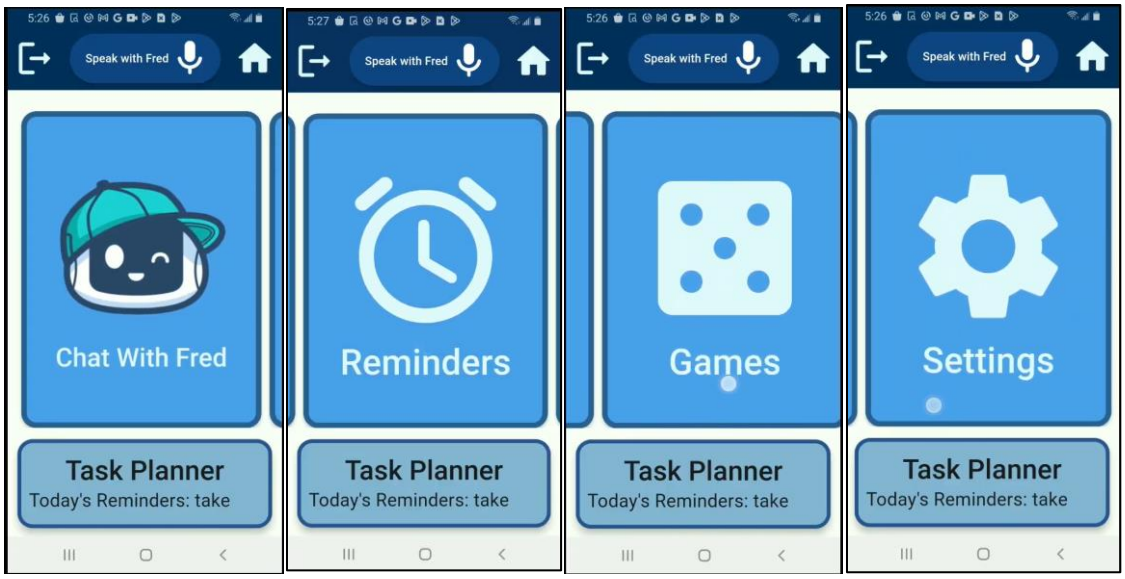

Figure 5: PWD app home screen.

1.2 Software Programs

In modern software development, understanding the flow of data and the underlying architecture of a system is paramount to creating robust and efficient solutions. This section provides high-level visual representations to illustrate design decisions made, offering invaluable insights for the continued development and maintenance of the FRED app. The data flow diagram and functional architecture provide a deeper understanding of the system's behavior and dependencies, paving the way for informed decision-making and a streamlined development process.

1.2.1 Data Flow Diagram of Person with Dementia Side of Application

In Figure 6, the FRED app contains its core functionalities for the PWD side: user account, task manager, memory card game, Sudoku game, and converse with FRED AI avatar. The red circles identify sensitive user data that is being passed to third-party entities. The third-party entities are the Firebase database, the default cell phone app, and OpenAI. The functions of marking a task done and playing a game do not transfer sensitive user data to the Firebase database. The simple security measures the NOVI team has incorporated into the FRED app include sanitizing user input, password salting and hashing, encryption, constraining user input, and limiting output tokens.

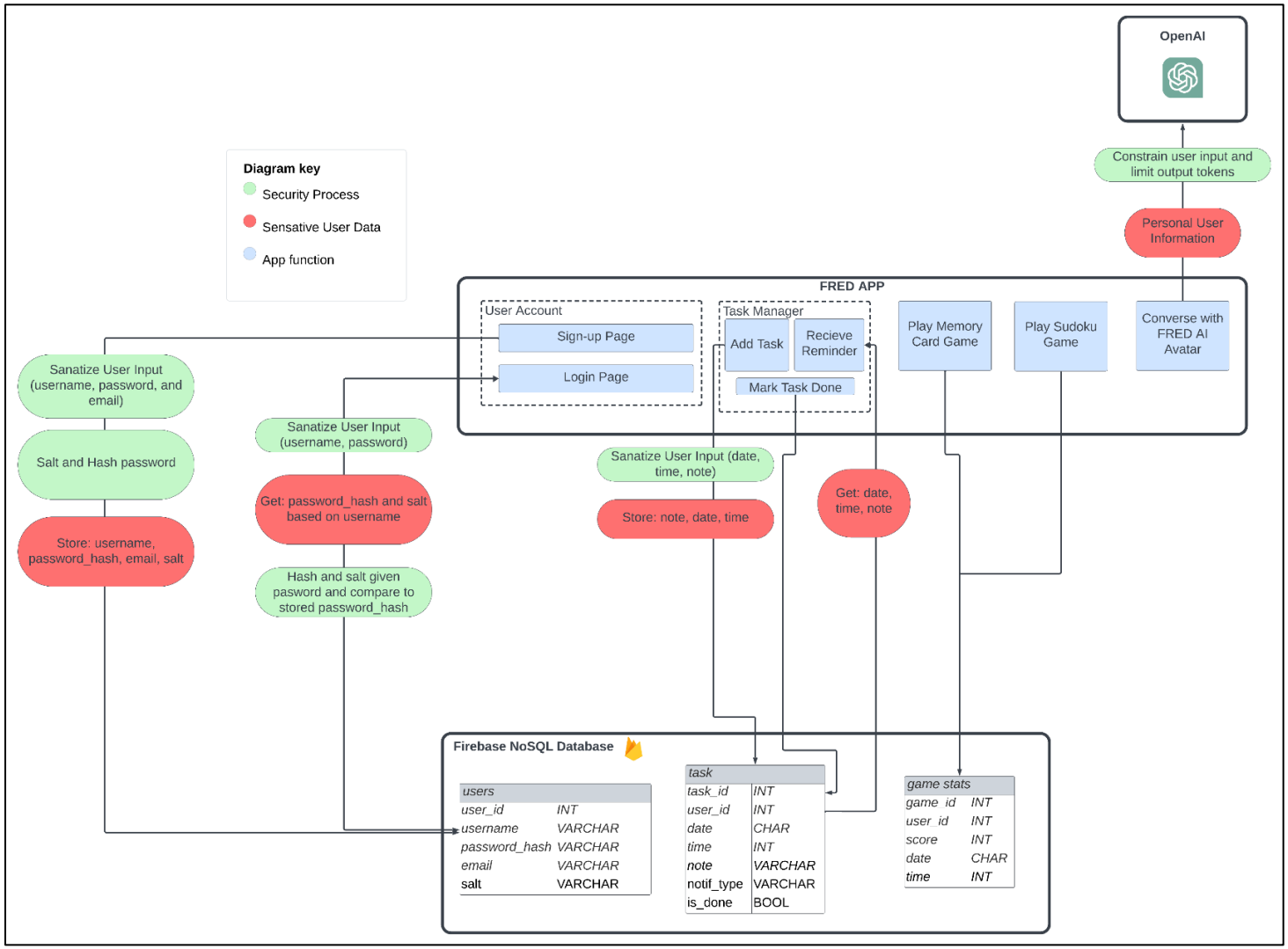

Figure 6: Data flow diagram for the FRED app PWD view showing the flow of user data between the app and third-party entities.

1.2.2 Functional Architecture of Person with Dementia Application

The architecture of the FRED app looks at its internal processes and organization from an engineering point of view as seen in Figure 7. The functional architecture includes the full system of the FRED application labeled by the box APP. Features are further compartmentalized by the gold boxes labeled by feature. The following parts of this section will detail each of these features and the subcomponents within them. Subcomponents are in white boxes connected to a yellow box which indicates the starting point of the feature. Labeled outside of the architecture are the other actors that provide inputs and outputs to the system. Inputs and outputs are labeled by a colored area and the correlating I/O. A legend of the I/Os is available in the bottom left corner. Additional I/Os are the interior of the system for interactions between the features and components of the system.

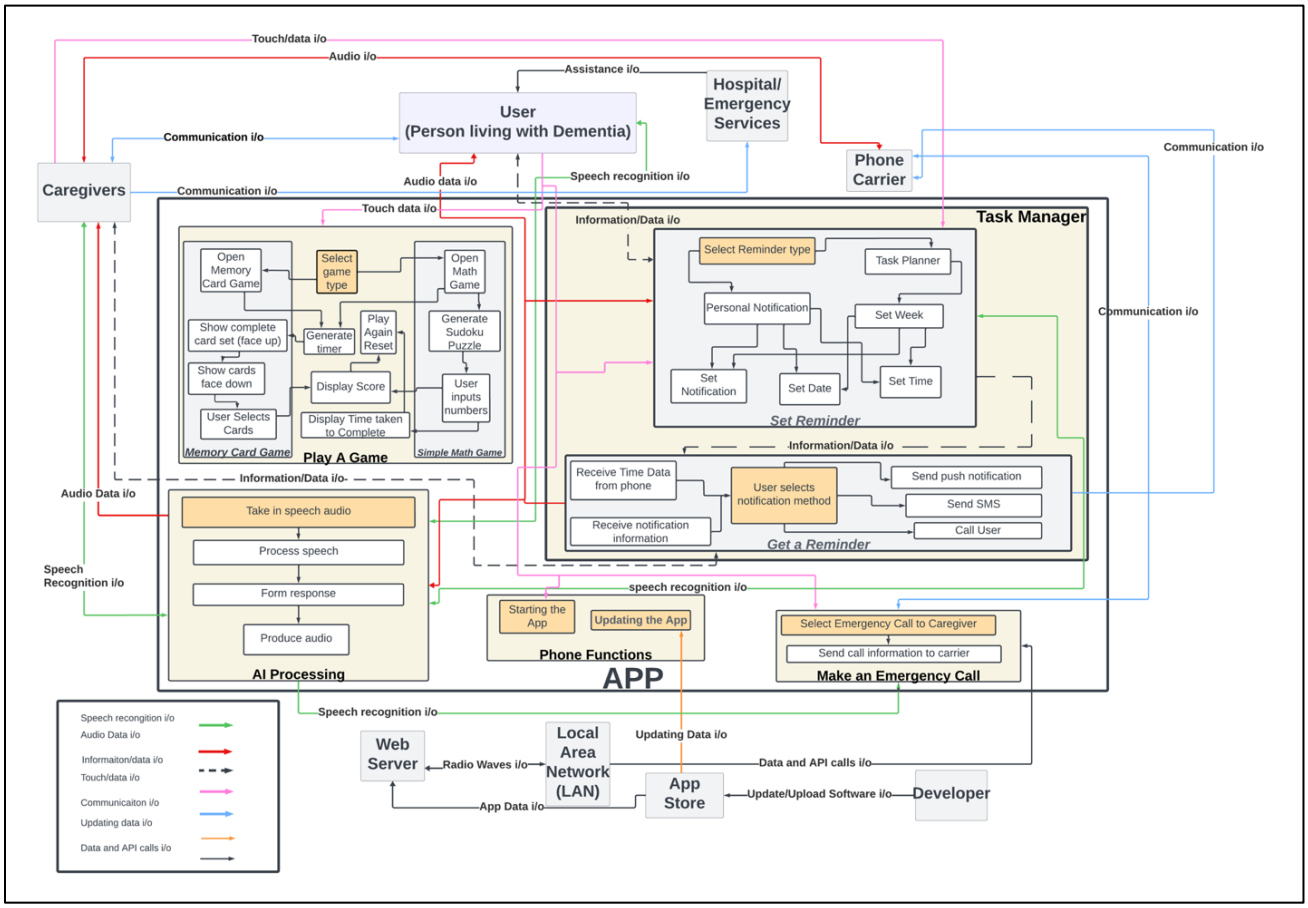

Figure 7: Functional architecture view of the FRED app system.

The components of the FRED app system include subcomponents detailing the included processing with each feature. Each feature is shown in the functional architecture and contained in a gold box. Inside the feature is a yellow box indicating the starting point of the feature, such as the initial action or page that will be interacted with. The arrow shows the progress of events through the feature with white boxes showing the actions taken to complete tasks within the feature. The play-a-game feature includes two of the game's users will have access to and the model that additional games may follow. The two games are components of the Play a Game feature with a game selection that is used once entering the feature. Figure 8 shows the process flow of the play-a-game feature.

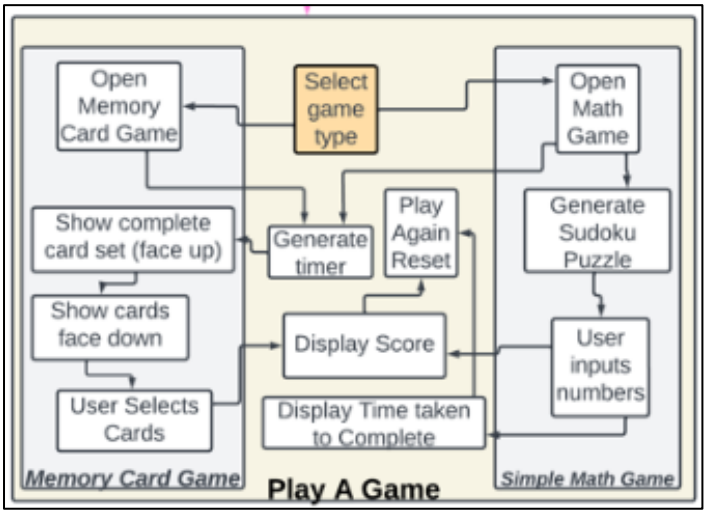

Figure 8: Component view of the play-a-game feature from the functional architecture.

The task planner features include two separate sub-features that interact with each other and are dependent on each other in many aspects. Figure 9 shows the architecture of the task planner features which includes setting a reminder and getting a reminder. For consolidation purposes, the interactive properties of the two sub-features are labeled as information or data. This does not show backend work such as API calls and the specific details of time, date, and text that is shared. The set a reminder sub-feature allows the user to set reminders and other tasks for a certain time and date. The get a reminder is the inverse of that, displaying the reminder that was previously set. For future development, the task manager feature will interact with reminders and tasks from the caregiver side of the app.

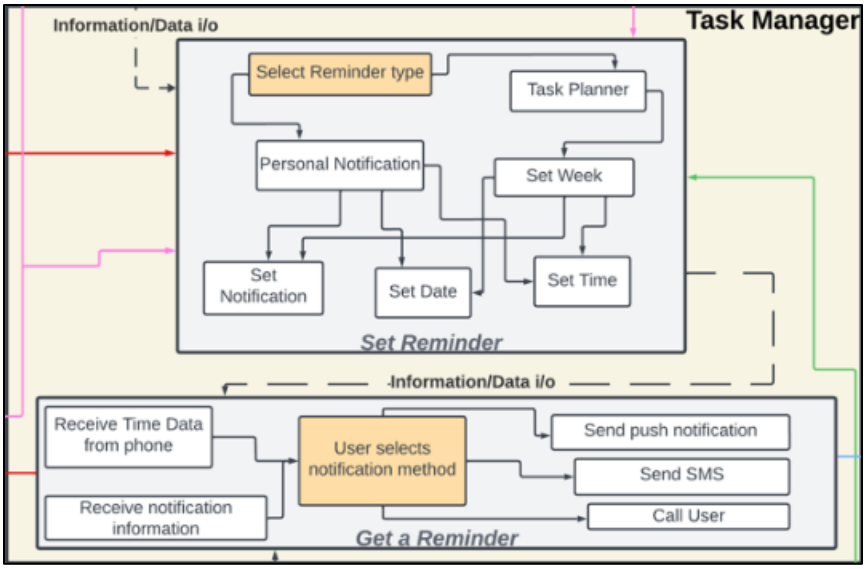

Figure 9: Subcomponents for the Task Manager sub-features from the functional architecture.

The functions of the AI chatbot are compiled into AI processing, which also includes the speech-to-text feature as seen in Figure 10. The phone will take in audio, process it, and respond to the user's speech through the FRED chatbot. This will use OpenAI software.

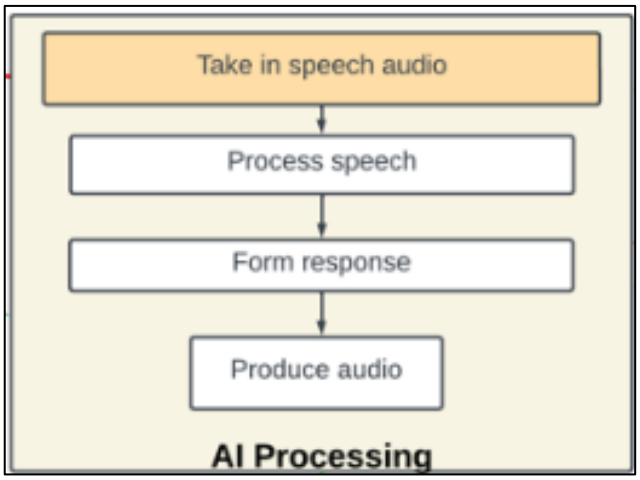

Figure 10: Process for AI chatbot from functional architecture.

The processes that are handled by the phone itself are covered in phone functions as shown in Figure 11. These are processes such as starting the app and updating the app. Features such as these and sending audio and visual information in the real world will be dependent on the phone working on the user's end. Starting and updating can be more directly related to development as crashes and errors during these processes can be altered by the development team.

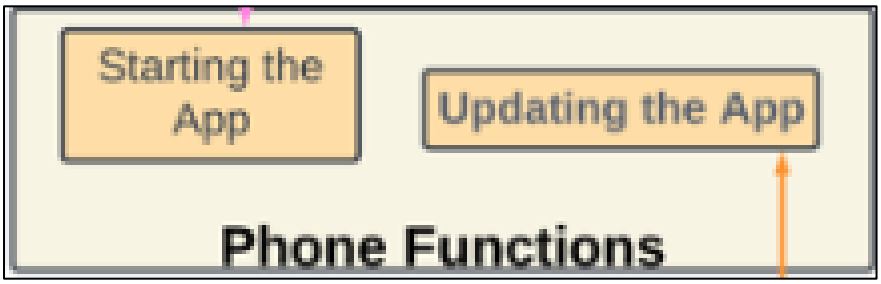

Figure 11: Phone functions component of the functional architecture.

1.3 Product Specifications

Include specifications related to testing. The product specifications are measures for testing how the product's final prototype adheres to the stakeholder requirements described in the NOVI PDR. Of these specifications, some have a larger importance to the success of the team in meeting these requirements, which are labeled as technical performance measures. Twelve specifications are included but only nine specifications will be involved in testing due to time and resource limitations. The specifications are listed in Table 1 and include the metric used for the specification along with the target value and direction of the value. Direction indicates if the value is desired to be higher, lower, or stable with progression.

1.3.1 S01 Task Completion Rate

This specification will measure how well users can navigate the app by having them attempt to complete a designated task within the app. Task Completion rate was not tested during the course due to the app not being to a level required for this testing. This will require functionalities for all the app's features. Task completion is judged by the user finishing the given task during a user test. User tests should be planned for early development phases to receive the most beneficial feedback on direction.

1.3.2 S02 User Feedback

NOVI expects to receive critical feedback from users based on the aesthetic design and ease of use. Feedback on user design will be taken from caregivers, PWDs, and University of Tennessee staff and students. The method of measurement was through Google Forms surveys which also received some verbal content. During MVP 2, the team had feedback surveys completed by classmates and attending personnel on their experience after using the app for a few minutes. Caregivers were given a survey about what they would need most in the caregiver side of the app. PWD surveys were not completed this year due to the team being unable to reach a population for testing. Feedback was positive in some cases, such as for the caregivers, but the team also received

some negative points from the MVP 2 results. Due to those results, the specification is not considered to have met the requirements set.

1.3.3 S03 Daily Time Spent on App

The daily time spent on the app will ensure customer requirements for engagement are met. Since this test requires users to measure the time they spend in hours per day for up to 6 months, the test could not be performed during this project. The team formed a test that can be used by future developers to determine if this specification meets requirements. An acceptable goal for this specification is to see use increase and become steady over time.

1.3.4 S04 Stress Testing

Stress testing will be performed to ensure the app can consistently produce the correct feedback. This test will be done in the future when the AI chatbot is in a user-ready state and when it has more connectivity with the application to navigate features. Multiple phrases and tasks will be input with the same expected output. Consistency of the output is what will be measured to determine if the specification is met. As the AI feature is improved, more phrases and tasks will be included in this test.

1.3.5 S05 Loading/Lag Time (App Connectivity)

Loading time may be tested by using stopwatches to determine how long it takes features to load. This specification was tested during MVP 2 and Final MVP where designs were ready to be modeled. The team would prefer to measure using the application on an actual phone, but this testing was done using the Flutter emulator. Customer requirements for this specification were met through low load times for all aspects of testing.

1.3.6 S06 Vulnerability

Security is a key part of the success of this app. This specification is designed to ensure that the correct protocols are used to keep users and their information safe. The team has plans to test the security of the app but will not complete these tests for this project. This is due to the layer at which the security is implemented which will heavily rely on 3rd party activity. Security testing will not be done during the prototyping of this project due to limitations in time and the lack of sensitive information currently in the prototype. The security testing should be performed by QUARK software. Since security was not implemented at this time, the specification does not meet customer requirements.

1.3.7 S07 Advertising

NOVI wants to reach as many people as possible who might be future subscribers to the FRED

services. It is difficult to reach the target audience, so advertising is an essential specification. The advertising specification is completed with the connections the team can make with ADRD-associated groups. No specific test is completed for this specification, but the team can describe some progress through its interactions with the Maryville caregiver group. Since the caregiver group has provided more input and widened the connections of the FRED program, this specification can be considered to meet the requirements for this project. To fully meet customer requirements, more connections will be needed as the team struggles to reach PWD groups.

1.3.8 S08 Comparable Price

The FRED app is expected to be competitive with other apps like it on the marketplace and will have to have a competitive cost. Since a definitive method of subscription has not been set and the final features are not set, the team has decided not to go through with testing this specification. With the advisement of Mr. Aaron Snyder, the team has determined that a Freemium model best suits the app. The free tier will consist of all the features outlined in the MVP for both the person with dementia side and the caregiver side. The additional tiers will be determined later once more user feedback is gathered. Currently, the FRED app is focused on building a strong user base.

1.3.9 S09 Cognitive Game Score

The cognitive game score is designed to see how well users are performing in the game features of the app. This may determine if the game features need to be altered in some way to improve engagement with the app. Due to the prototypes having limited functionality of the app's gaming features, this specification will not be tested until the app is fully developed. The testing methods for this specification will have the user play the two games during extended user testing. The two games may implement two methods of measurement as the team further develops the games' processes. The current measurement will be the improvement of game scores from subsequent attempts at playing.

1.3.10 S10 Mood Improvement

The team expects the app to improve mood through engagement and consistent use. Due to constraints on available time and resources, the team is not implementing this specification's test plan. The mood survey feature will not be included in prototypes before the submission of the final report and therefore will not be included as a full function. Alternatively, the team plans to test this specification by having users record their moods using a written, digital, or verbal survey during user testing. This specification's test plan would require extended user testing. Positive results would see about a 10% increase in overall mood with narrow fluctuation during the testing time.

1.3.11 **S11 Typeface**

This specification has been added to address concerns of practical design and accessibility. The test for this specification is performed by a distance reading test and is named the typeface test. This will have a participant read the text from the FRED chatbot at set distances of 20, 40, 60, and 80 inches to simulate sight difficulties. The participant found difficulty in seeing the text from any extended distance. This test failed to meet the requirements for accessibility and will need to be improved for future development.

1.3.12 **S12 Color Contrast**

The color contrast specification is important for readability in the app to ensure that components on the screen can be distinguished while also providing an aesthetically appealing design. The WebAim color contrast checker will be used to perform this test. The color checker will show the contrast between two hex codes of color and will determine if the contrast meets the requirement for text and components concerning WCAG standards for accessibility [1]. This test was performed during the development phase of MVP 1 to ensure the design progresses with an approved color scheme. The test passed for colors that are used together in the app. This specification met the requirements for accessibility and aesthetic design.

Table 1: Product Specifications with metrics used to measure along with the desired target and the direction of progression to that target.

No.	Specification	Metric	Target	Direction
S01	Task Completion Rate	% Completed Tasks	>90% completed tasks	up
S02	User feedback	Average rating	>80% avg rating	up
S03	Daily time spent on app	Time in hours	>2 hours daily	up
S04	Stress testing	Response accuracy	Progressively higher use	up
S05	Loading/lag time	Time	<1 second load time	down
S06	Vulnerability	Count Vulnerabilities	Less than 3 Potential Vulnerabilities	down
S07	Advertising	Connections	Increase connections to local ADRD centers	up
S08	Comparable Price	Price of App	Low cost than comparable app	down
S09	Cognitive Game Score	Score on Game	70-90% score avg	stable
S10	Mood Improvement	1-5 survey	.9+ Avg improved mood	up
S11	Typeface	% Correct	90% correct	up
S12	Color Contrast	Pass/Fail	All Pass	up

Selected specifications and acceptance tests are used to judge the progress of the project overall toward meeting the key requirements of the stakeholders. Table 2 shows the technical performance measures which are this selected specification and their progress through the year along with the target value. Green spaces indicate a target is met and yellow indicates a target is close to being met. Red indicates a target is not met. The specifications were chosen based on the ability of the team to test them and their importance in adhering to the scope of work for the project. S02 User Feedback helps orient the direction of development, ensuring that all aspects of the app meet the needs of the population it is designed for. S05 Loading/Lag Time was divided into two tests for the specification which now includes App Connectivity. This is because connectivity is a similar goal to the original specification but requires a slightly different test to determine if it meets the requirements. Loading/Lag Time was chosen to ensure that the app is usable with no extended times to load content. This is an aspect of accessibility and engagement. App Connectivity ensures that the app is fully connected when it is called to load. Errors in this TPM would result in crashes which would affect the entire prototype. S12 Color Contrast was chosen due to its importance in accessibility. Poor performance in this aspect would have a drastic effect on most front-end design details and specifications.

Table 2: Technical Performance Measures

TPM	Target	PDR	SLDR	QRB1	QRB2	FDR
S02 User Feedback	>80% rating form surveys	n/a	n/a	n/a	<80%	
S05 Loading/Lag Time	<1 second load time for pages	n/a	<3 seconds	<1 second	<1 second	<1 second
S05 Typeface	>90%	0%	0%	20%	40%	
S12 Color Contrast	Pass WCAG tests	pass	pass	pass	pass	pass
conditions	Red = unmet	Yellow = in trouble	Green = met			

1.4 Person With Dementia User Interface

This section will go over the developed features for the PWD app. Included are pages from the final prototype and descriptions of the feature's processes. Features in the final prototype are games, the AI chatbot, reminders and the task planner. The emergency calling feature from previous designs was eliminated after the team reevaluated the practicality of the feature.

1.4.1 **Games**

Games included in the person with dementia side will be sudoku and a memory card game. These games can be accessed through the home page's games component. The games were chosen due to the ability of the software developers on the team to be able to complete them within the timeframe of the project as well as other factors such as the memory card game which is a remnant of the FRED robot. Both games include an instruction page, showing the user how to play, which is shown on the left page of Figure 12 for the memory card game. The memory card game is played by displaying a 3x4 grid of 12 cards that have 6 matching pairs. The cards are displayed for a short time before the user will advance to the next stage of the game. In this next part, the cards will flip over showing the same color block across the grid. The user will then select two cards and if the cards match the user has succeeded in the task and is encouraged to continue to play until all cards are matched. If the cards do not match the game will flip the cards back over allowing the user to continue to play until all cards are matched. At the end of the game, the user is displayed a page congratulating the completion of the game and allowing them to exit the feature or play again. Figure 12 shows the process of the game from the team's final prototype.

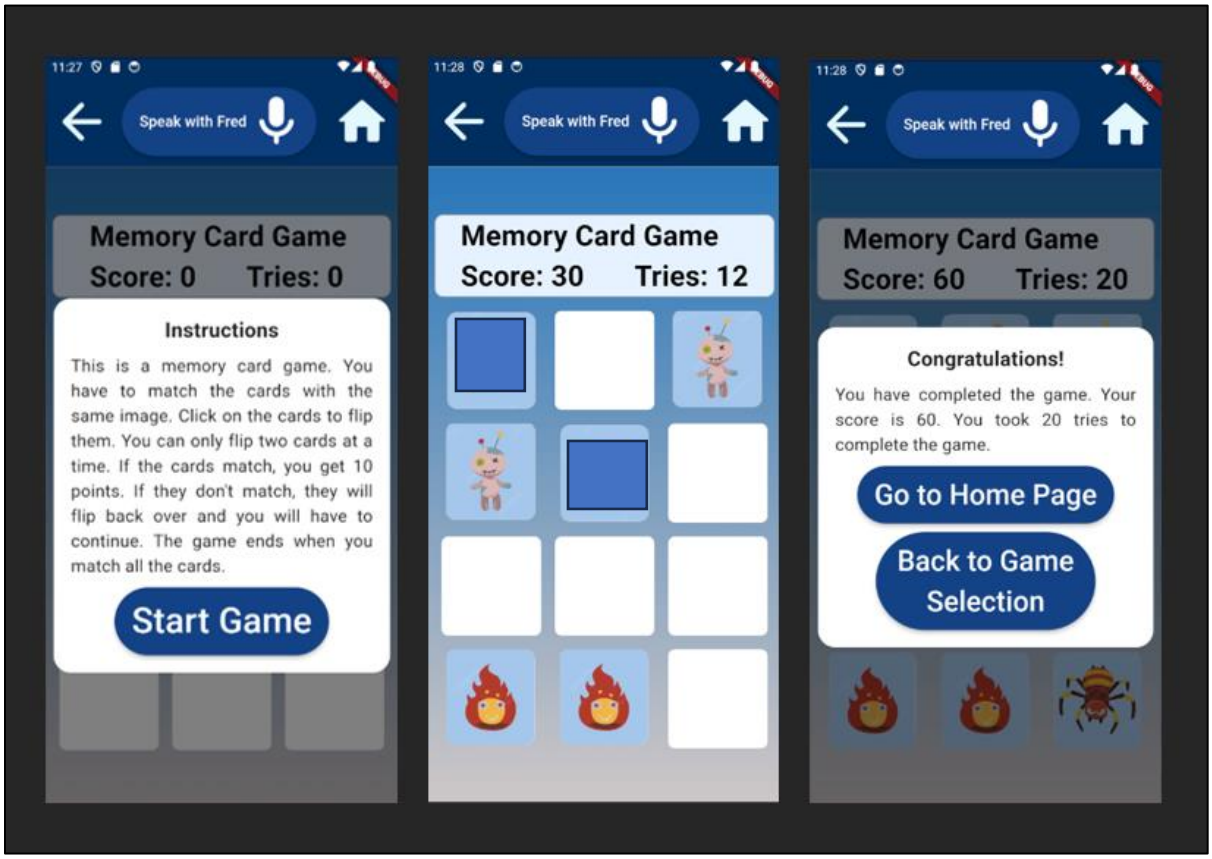

Figure 12: Memory Card game UI with instructions, gameplay, and congratulations end page.

The sudoku game is played the same as the traditional game. The user will be given a large grid up to 9x9 which is further split into 3x3 blocks with numbers partially filled in. Numbers can only appear once in a nine-space block and once in a column or row. Figure 13 shows this feature at some point early in a game from the team's final prototype.

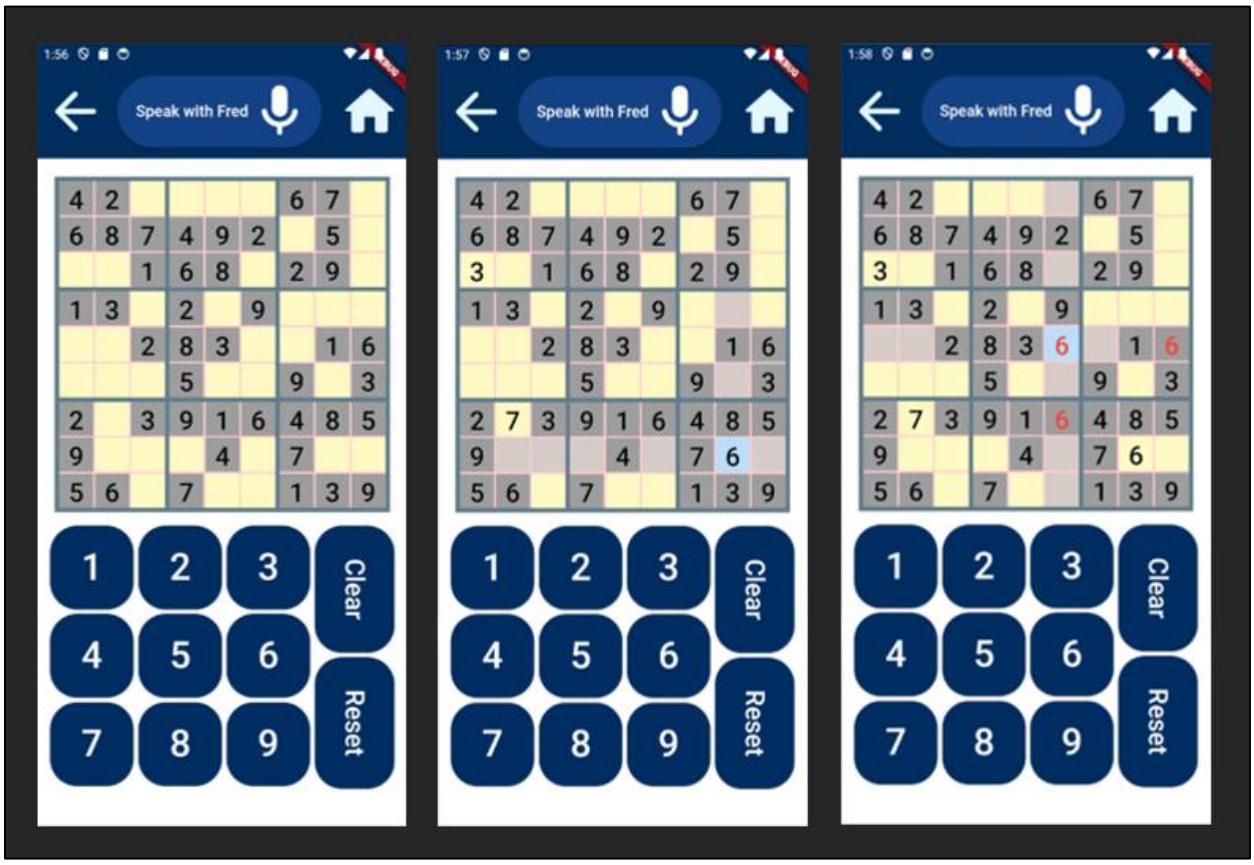

Figure 13: Sudoku game page in the middle of a game.

The game is designed to be usable and accessible for persons with dementia and elderly individuals. This includes having buttons to clear and reset selections within the game and a designated number pad. The clear button allows users to erase a previous selection or a current selection. The reset button will reverse the previous actions of the user. The space being edited is highlighted, clearly showing where the user is on the screen. If a number is occupying that space, all matching numbers are also highlighted as well as the full column and row. This may help individuals see what their goal is to fill in the space.

1.4.2 **Chatbot**

The FRED app includes an AI chatbot that allows users to interact with a conversational AI. Since the demographic focused on this project often experiences hallucinations and short-term memory

difficulties, the chatbot has been tailored to provide responses that are more safeguarded than general open-source chatbots. The AI is sourced from OpenAi's ChatGPT. More considerations are included in subsequent sections of this report. The chatbot can be accessed through the chatbot component of the home page. Accessibility features of the chatbot include speech-to-text, as requested by the project sponsor. This allows users to speak to FRED which will subsequently display their words in text, allowing FRED to respond without the difficulties users might experience in typing out their thoughts or questions. Figure 14 shows the coded user interface of the feature.

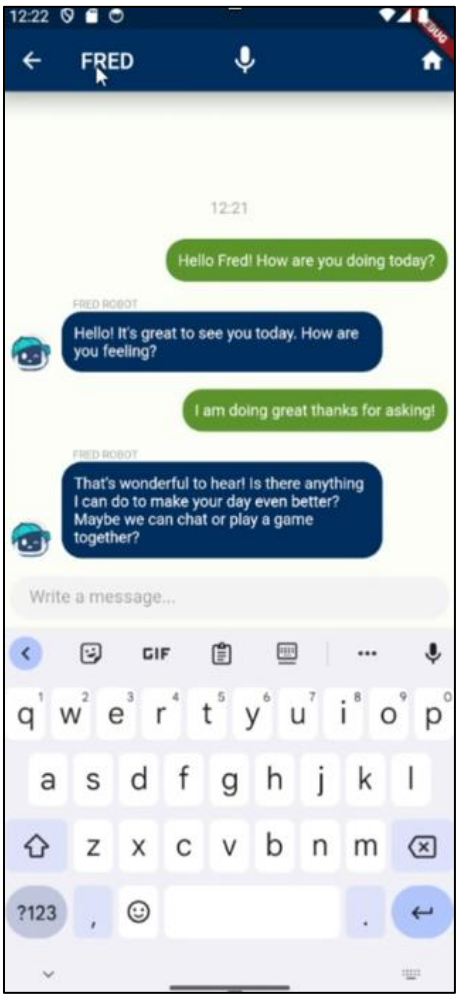

Figure 14: Screenshot of an emulator for the AI chatbot.

The speech-to-text function can be accessed through the microphone at the top of the page. This can also be seen on the home page of FRED. As shown in the home page speech-to-text screenshot displayed in Figure 15, a microphone button will appear in the middle of the screen when the icon is selected along with two buttons.

Figure 15: Screenshot of speech-to-text demonstration.

Selecting the check marked green button will indicate the user accepts the speech recognition and will input the text for FRED to respond. The red x button will exit the speech-to-text function without inputting any text for FRED to respond to. Privacy considerations for this feature are included in subsequent sections of this report.

1.4.3 **Reminders**

The reminders section can be accessed through the reminder component of the home screen as seen in Figure 16. This feature allows users to set reminders and tasks for a certain time and date. The interface is designed to be simple to use only including the buttons for time and the description of the reminder. The top three toggles are colored blue and are meant to indicate the date the

reminder is to be set. The lower three toggle buttons are colored green and indicate the time of day the reminder is to be set. Finally, to ensure the user knows where to verify the reminder is set, the set reminder button is placed at the bottom and is scaled to be large and noticeable compared to other aspects on the screen. Reminders that have been set will appear in the task planner feature.

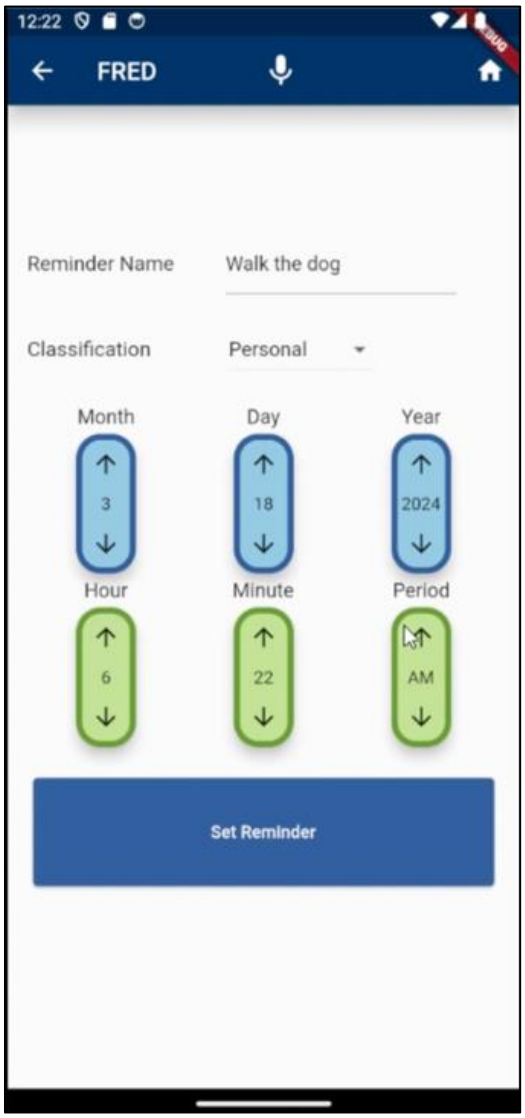

Figure 16: Image of the reminders feature from the app emulator.

1.4.4 **Task Planner**

Task planners will receive information from reminders and display them in daily, weekly, or monthly views and allow users to interact with the task to see the time and description. Figure 17 demonstrates how this looks in the emulator UI with the daily view. Tasks and time are separated

into columns so that each is indicated. A toggle switch at the top allows changing between the daily, weekly, and monthly views for users, and just below that the current date, week, or month that is selected will appear. Future iterations will allow greater control from the caregiver side by setting reminders and actions that will be implemented into the task planner.

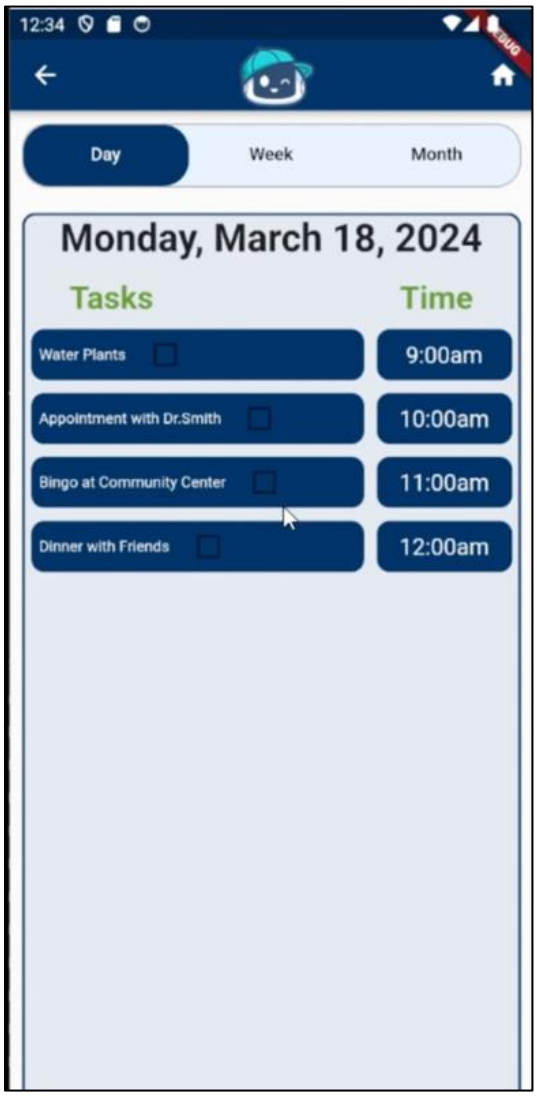

Figure 17: Screenshot of the daily view from the task planner feature.

1.4.5 **Emergency Call**

The emergency call feature was deleted due to usefulness and narrowing development.

1.5 Caregiver User Interface

The caregiver side of the application is designed to support caregivers and those who regularly interact with the person with dementia. It includes educational resources as well as daily management and self-help tools. This section will lay out the groundwork for the future development of a fully integrated iteration of this design. The features chosen to be included in the caregiver's original framework are an information page, a community page, a loved ones page, and a self-care page, which are further described in the following subsections.

1.5.1 Information

The information feature focuses on the educational aspects of caring for a person with dementia. Primarily parts of this will be courses and information. There is an abundance of information on dementia care that can be accessed through the internet, but finding this information can be difficult, so the FRED app aims to simplify this process. Figure 18 shows the UI of this page. Additionally, Figure 19 shows the UI of a new research page. This will be included to help provide the most up-to-date information on the research involving Alzheimer's and dementia. A user can read more about the study as well as choose to sign up to participate in the study. This allows researchers to get access to their target audience.

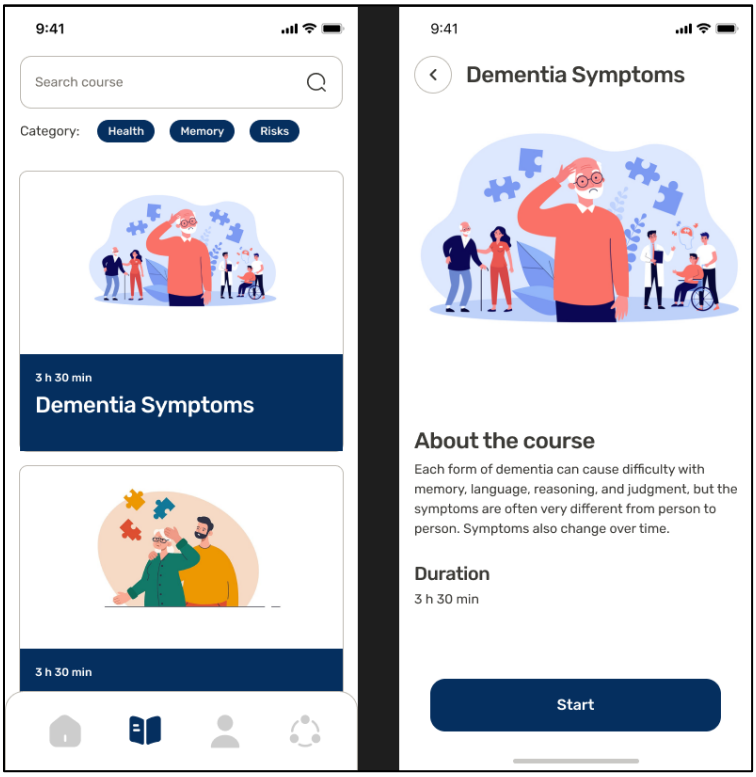

Figure 18: Caregiver Courses Page

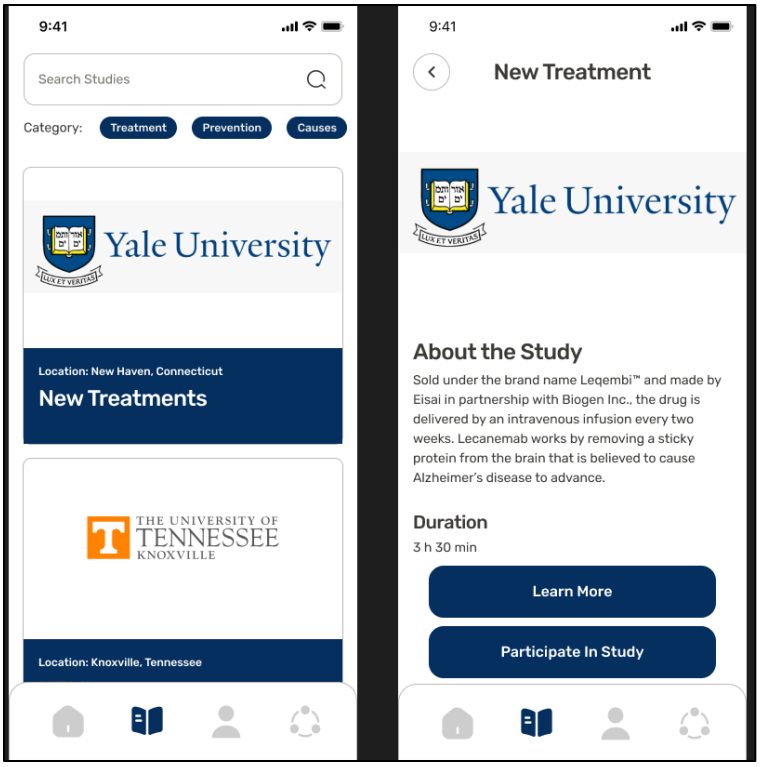

Figure 19: New Research Page

1.5.2 **Community**

The community feature of the FRED app offers a vital platform for fostering connection and support. Within this feature, users can access a local community page to find nearby support groups and community events, providing crucial opportunities for interaction and shared experiences. The inclusion of discussion boards covering various caregiving topics not only facilitates knowledge exchange but also serves as a source of emotional support. NOVI hopes to ensure a safe and trustworthy environment, mitigating the presence of trolls and fostering a sense of community authenticity. Additionally, local resources such as adult centers, memory care facilities, and at-home care companies can advertise on the platform, offering caregivers valuable information and support. The *Find a Friend* page further encourages personal connections among users, while the monthly calendar helps caregivers stay informed about local events and support group meetings. Moreover, the provision of a dedicated *My Caregiver Group* for group chat support and the option for users to engage with an AI chatbot during moments of loneliness underscores the app's commitment to addressing the multifaceted needs of caregivers. In summary, NOVI's community feature plays a pivotal role in providing caregivers with not only practical resources but also invaluable emotional support and a sense of belonging in their caregiving journey. Figure 20 shows the preliminary design for this page. This will be updated to include the functions mentioned above.

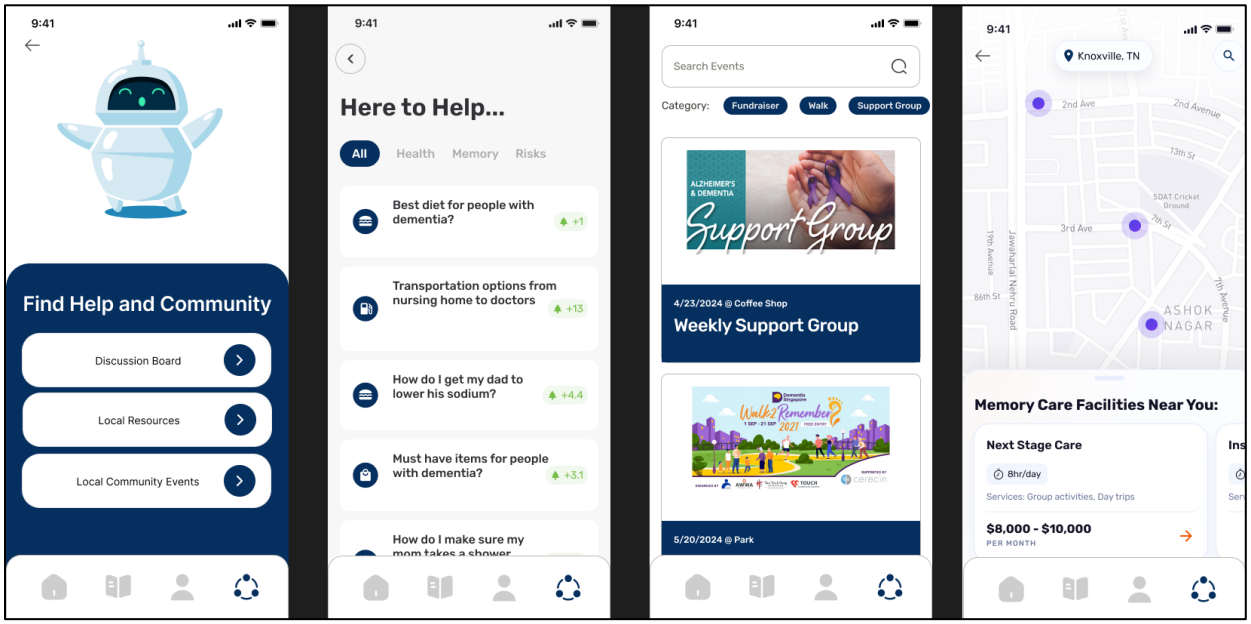

Figure 20: Community/Social page example for caregiver app.

1.5.3 **Loved One**

The *Loved Ones* tab within the FRED app serves as an indispensable tool for caregivers to be able to monitor and manage the well-being of their loved ones. Figure 21 shows the UI of this page. Through this feature, caregivers gain real-time insights into their loved one's whereabouts with the display of their current location. Activity levels, including the number of steps taken, can be tracked, and synced with Apple Watch for seamless monitoring. Caregivers can also manage tasks and reminders within the app, adding or removing them as needed, and keeping track of completed activities such as eating and medication intake. The inclusion of medical and activity notes fosters communication among different caregivers, allowing them to share important information and updates. Furthermore, the feature offers charting capabilities, medication logs, and journaling functionalities, enabling caregivers to comprehensively track their loved one's health and progress over time. By centralizing these essential caregiving tasks and information in one accessible platform, NOVI's *Loved Ones* tab empowers caregivers to provide optimal care and support for their loved ones with dementia.

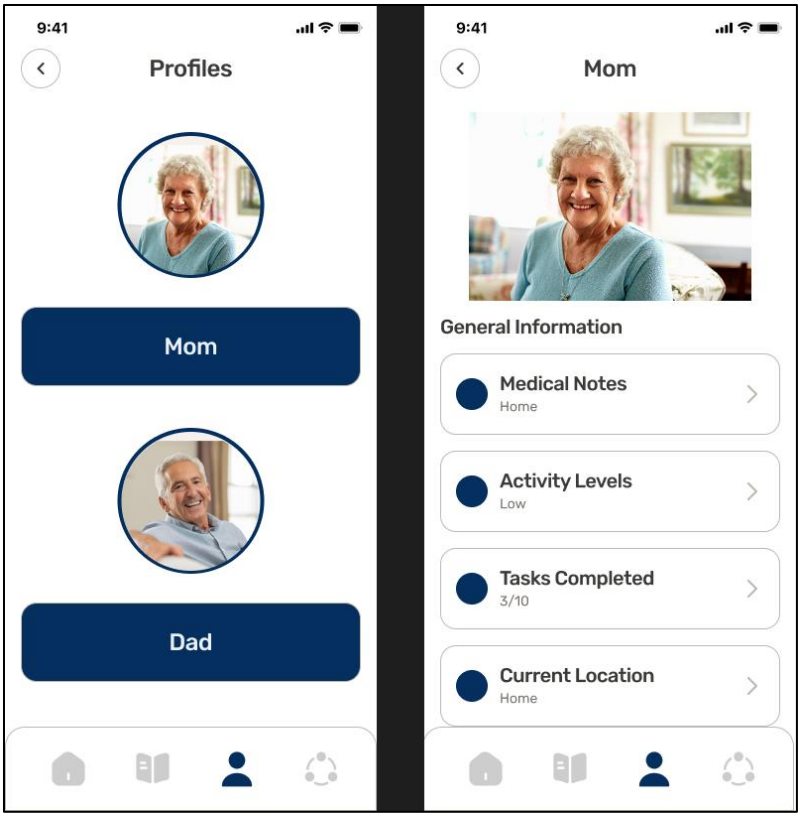

Figure 21: Caregiver Loved Ones Page

1.6 **Test Procedures**

System and feature testing is done to determine the front-end and back-end elements required for each feature. The software team will use them to organize what is incorporated in the UI and what is incorporated into functional code. Table 3 shows the features of the FRED app along with the frontend and backend components involved with each feature. In this table, the front-end components can be seen or interacted with. Backend components are processed through code and may not be seen visually. This testing was completed and referenced at different stages in development as the software team improved the prototype and finished features.

Table 3: System testing for each feature organized by frontend and backend.

Feature	**Frontend**	**Backend**
Sudoku Game	- game start/settings page UI (start game, easy/medium/hard level) - game finished page UI (game score, play another game, go to home page) - game sudoku board page UI	- show game timer - keep track of game score - generate game board - responds to user input
AI FRED Chatbot	- FRED avatar UI - FRED chatbot page UI	- adjust input settings for ChatGPT - adjust output settings for ChatGPT - format and display inputs and outputs - voice recognition - text to speech
Task Manager	- task manager icon on home page - task manager set reminder UI - task manager get reminder UI - task manager calendar view UI	- update task manager icon on home page w/ top three task - store reminder info in database - send notification for reminder - populate calendar view with task
Speech to Text	- microphone icon/button	- setting up Google Cloud Speech-to-Text API - capture user's voice input - process and interpret commands
User Account	- login-page UI - register page UI - home page UI	- hash and salt password - store username, password digest, email to database - validate user login attempt
Memory Card Game	- game start/settings page UI - game finished page UI - game board page UI	- show game timer - keep track of game score - generate game board - responds to user input

Unit and Integration testing is performed to determine whether each feature’s internal components are functional and connected to the correct input and output. In Table 4, a sample of an integration test for the sudoku game is shown. This includes the function within the game, the inputs related to the function, and the output that should be produced by that input. This is performed for each feature. This is not included in acceptance testing as this process is done by the development to organize development rather than test the function itself. The complete integration testing is shown in the appendix.

Table 4: Sudoku Game Integration Testing Example

Sudoku Game		
Function	Input	Output
User starts Sudoku game		
	User clicks Sudoku icon on home page	game start/settings page is displayed
	User inputs level of difficulty	
	User hits start game button	game sudoku game board displayed
User plays game		
	Game board with empty sudoku board displayed to User	
	User inputs numbers	numbers are displayed on game board

2. Commercialization Plan

The commercialization plan for the FRED app is a critical aspect of getting FRED into the hands of more people. This section outlines potential revenue streams, a freemium model, maintenance costs, and user milestones. Through a thoughtful and strategic approach to commercialization, the NOVI team aims to not only generate revenue but also build and foster long-term relationships with FRED users.

2.1 Revenue Streams

The NOVI team strategically added a caregiver side to the FRED app to strengthen the business model by opening 2 potential revenue streams. These revenue streams can help offset costs and allow a base version of the FRED app to be free to users. This aligns with our *product with a purpose* mission statement by providing no monetary barrier to accessing the value the FRED app provides for people with dementia and their caregivers.

The social tab on the caregiver side has a local community page where caregivers can find local support groups and community events. Local resources such as adult centers, memory care facilities, and at-home care companies would pay to advertise on this page. This is mutually beneficial as companies get direct access to their target market and users are informed of the resources locally available.

The research section of the social tab provides current research being conducted for the diagnoses and treatment of Alzheimer's and dementia. The FRED team has personally experienced the struggle of getting willing and able participants to provide valuable user feedback on the design and functionality of the FRED app. This is a vulnerable population where extra protection and

precautions need to be in place when collaborating with them. Therefore, allowing researchers to pay to post their new research on the FRED app to either receive feedback or ask for participants would greatly help researchers in progressing advances in the diagnosis and treatment of Alzheimer's and dementia.

2.2 Freemium Model

The number of active users is key to the success of the FRED app. Therefore, the NOVI team emphasizes the importance of recruiting and retaining new users. Therefore, the NOVI team recommends that the FRED app use a freemium model when trying to monetize the app. This allows the FRED app to attract a large user base with a free version of the app while offering premium features for users willing to pay. This flexibility can help maximize user acquisition, engagement, and revenue potential over the long term. Additionally, the freemium model aligns with the *product with a purpose* and allows users to try before buying to foster a sense of trust between users and FRED.

There are several monetization methods for apps, each with its advantages and disadvantages. The NOVI team decided not to recommend a paid app, in-app advertising, or a subscription model for several reasons. A paid app requires users to pay upfront to download and access the app. This may limit user acquisition as some users may be hesitant to pay without trying the app first, and therefore, limit the number of people the FRED app can help. In-app advertising could be integrated into the FRED app, but excessive or intrusive ads can negatively impact the user experience. The company's advertising would have to be thoroughly vented to ensure they are not trying to take advantage of a vulnerable population. The NOVI team initially recommended a subscription model but decided that convincing users to commit to recurring payments can be challenging. In this model, serving a population that is forgetful did not align with the *product with a purpose* mission of the FRED app.

While all these monetization methods have their merits, the NOVI team recommends a freemium model for the FRED app because it combines elements of both free and paid apps. A freemium model is a pricing strategy by which a basic product is provided free of charge, but money is charged for additional features or services that expand the functionality of the free version of the app. The value of the FRED app comes from the community and information it provides in one central location. There is limited direct competition with the FRED app. However, many of our competitors offer their services free. Therefore, the free tier of the FRED app will be the MVP that includes the core features of the caregiver side and person with dementia side outlined in the software programs section of this report. This is also the version that will be distributed to a pilot group. The other paid tiers would include other features not in the MVP such as more chatting time with the chatbot or more data storage for medical notes. The NOVI team also recommends a referral system to help reward users. Users of the FRED app could have a referral link that gives them credits towards their account when a new profile is created using their referral link.

2.3 **Maintenance Cost**

Currently, it is hard to estimate final business costs as the FRED project is still very much in the product development stage. The NOVI team does know that as more features are added, the costs of app development and maintenance increase. It is important to consider maintenance costs now as the NOVI team anticipates that the FRED app will be maintained by Dr. Zhao's research lab. The FRED app is intended to be a revenue stream to help fund Alzheimer's and dementia research happening in Dr. Zhao's lab. Therefore, the maintenance costs need to be kept low to not divert money and resources from the main research.

The NOVI team used an app development cost calculator that asks a series of questions to determine the complexity of the app. This includes things such as notification types, in-app purchases, and login features. The final estimate to complete the FRED app is $300,000 - $400,000 based on a team of 4 being paid $50 per hour. This initial half-a-million-dollar investment to create a FRED MVP is cheap compared to other projects that include hardware manufacturing. The specific answers to the questions and the final estimate can be found in Appendix A.

Many people might believe that once an app is built, there are no other costs associated with it, especially if new features are not being added. However, things are constantly changing such as phone updates, third-party API call updates, and customer needs. Therefore, part of the company's budget should be allocated to maintenance costs to protect against and resolve software bugs caused by various factors. The standard practice in the software industry is to budget about 15-20% of the original cost of developing the app per year for maintenance [2]. Therefore, the maintenance costs for the FRED app can be estimated to be around $85,000 annually. This app had been built by entry-level software engineers. Therefore, the NOVI team anticipates even higher maintenance costs to resolve software bugs found through more extensive testing. To make a successful app that users will be willing to pay for, the NOVI team highly suggests that a good amount of money is set aside for maintenance costs, especially as the FRED user base grows.

2.4 **User Milestones**

For the launch of the FRED app, it is important to focus on growing the user base to build a strong community platform. The journey begins with the Minimum Viable Product (MVP) launch then progresses to user engagement and lastly revenue generation.

The initial phase involves launching the MVP to a select group of users through a beta pilot program. This program aims to gather feedback from early adopters, refine the app's features, and ensure its usability and effectiveness in addressing the needs of individuals with dementia and their caregivers. This phase should have a goal of gaining around 1,000 users within the Knoxville area so that Dr. Zhao's lab can closely monitor user interactions, identify potential issues, and iterate on the app's design and functionality before scaling up to a wider audience.

As the app gains traction and garners positive feedback from beta testers, the focus shifts towards user growth. Leveraging insights gained from the pilot program, the team implements targeted

marketing strategies to attract more users to the app. This may involve collaborating with healthcare professionals, advocacy organizations, and community support groups to raise awareness about the app's benefits for people with dementia and their caregivers. Additionally, optimizing the app's visibility on app stores and leveraging social media and content marketing can help drive organic user acquisition. Metrics such as the number of active users and retention rate can be used to measure the success of this phase.

Once a solid user base has been established, the team can explore revenue generation opportunities through the implementation of a freemium model as well as reaching out to companies and research groups for advertising. Metrics such as conversion rate, average revenue per user, and customer acquisition cost can be used to measure the success of this phase.

3. Ethical and Privacy Information

The NOVI team has developed a mobile app aimed at assisting people with dementia and their caregivers to help improve their quality of life. However, it also raises several ethical and privacy concerns that need to be carefully addressed when working with a vulnerable population. The FRED mobile app's intended purpose is to help and should not be used to replace human interaction and care. Additionally, the app will be handling sensitive personal information, and it is crucial to implement robust security practices to protect user privacy.

3.1 Ethics of AI

In today's digital age, where information is abundant and constantly vying for our attention, the attention economy plays a significant role in how technology platforms operate. Many mobile apps like YouTube, Instagram, and Facebook are designed to keep users' attention which is then translated into economic value like advertising and personal data. However, the NOVI team has established a business model where economic value is created by helping connect people and providing valuable resources to an underserved population.

A differentiating feature of the FRED app is the artificial intelligence (AI) chatbot used to provide social companionship to people with dementia who often suffer from loneliness. This feature was included based on the request of Dr. Zhao as it aligns with his research interests in social robotics, AI, and dementia care. There is limited and inconclusive research on the possible benefits and limitations of an AI chatbot being used to provide social companionship for people with dementia. In one study, participants noted a need for an avatar in combination with a voice-based virtual assistant to help with executing tasks on their phones [3]. However, several participants noted the importance of providing human assistance in high-stress or intense brain fog instances where technology assistance is rendered useless. It is also widely known that many people with dementia suffer from hallucinations. Therefore, the use of an AI chatbot that is trying to mimic human conversation could cause extra stress and confusion for a PWD.

3.2 **Privacy Concerns/Considerations**

The person with dementia and caregivers should be informed about the data that is being collected and how it is being used in the FRED app. The medical notes feature of the caregiver side will hold sensitive information such as medications and test results. This data will not be sold to third parties and is intended to just be used by the FRED app to help keep track of PWD's health and progress. PWDs should be aware of the location tracking feature of the FRED app and be able to provide informed consent to be monitored.

User data will be stored in a Firebase database. The Firebase Realtime Database is a cloud-hosted NoSQL database that lets us store and sync data between users in real time. Firebase already implements robust security protocols to ensure user data is protected. However, it is up to the developer to configure the database properly. There have been numerous instances of leaked user data because of misconfigured Firebase databases [4]. Hackers are more motivated to steal user data from the FRED app because it contains personal information about a vulnerable group of people.

Another major privacy concern would be the use of personal data in the training of the AI model provided by OpenAI for the chatbot feature of FRED. Especially if the PWD accidentally inputs information such as social security number or credit card information prompted or unprompted into the chatbot. OpenAI emphasizes that models that are accessible via the API are versioned and have completed training. Therefore, they are not retrained or updated in real-time with API requests [5]. Additionally, data uploaded by users for fine-tuning and customization of the chatbot is solely used to customize that user's model. It does not flow into OpenAI's general training data. OpenAI does retain ownership of fine-tuned models, however, access is exclusive to the user who provided the training data [5]. As OpenAI continues to evolve, the FRED app needs to keep up to date with its privacy and security policies to ensure they align with the FRED app's goal of keeping users' data safe and secure.

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[2] K. Hunt, "What Does It Cost To Maintain An App," iversoft, 29 November 2022. [Online]. Available: https://www.iversoft.ca/what-does-it-cost-to-maintain-an-app/#:~:text=Standard%20practice%20in%20the%20software,about%20%2420%2C000%20annually%20for%20upkeep. [Accessed 26 March 2024].

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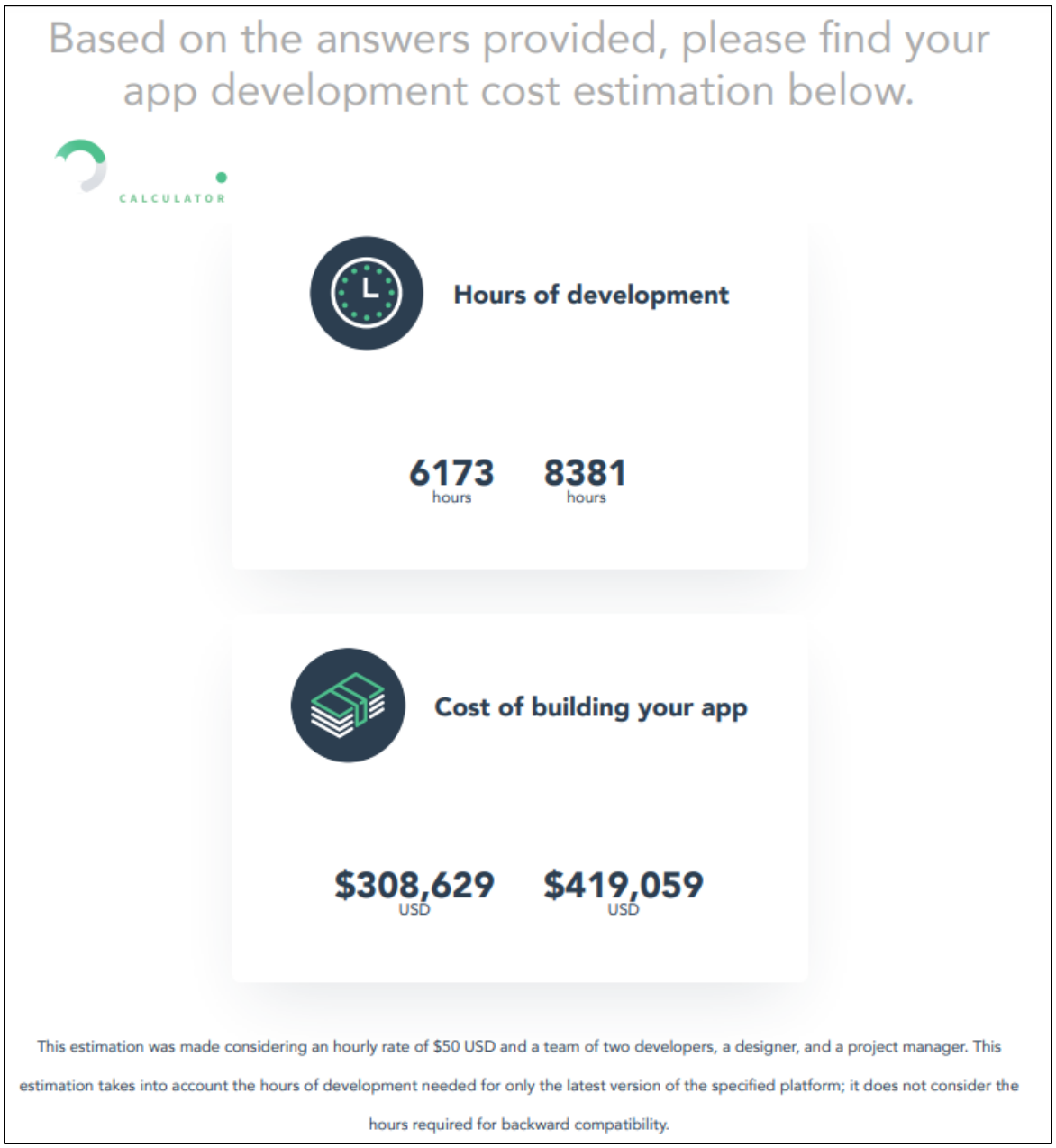
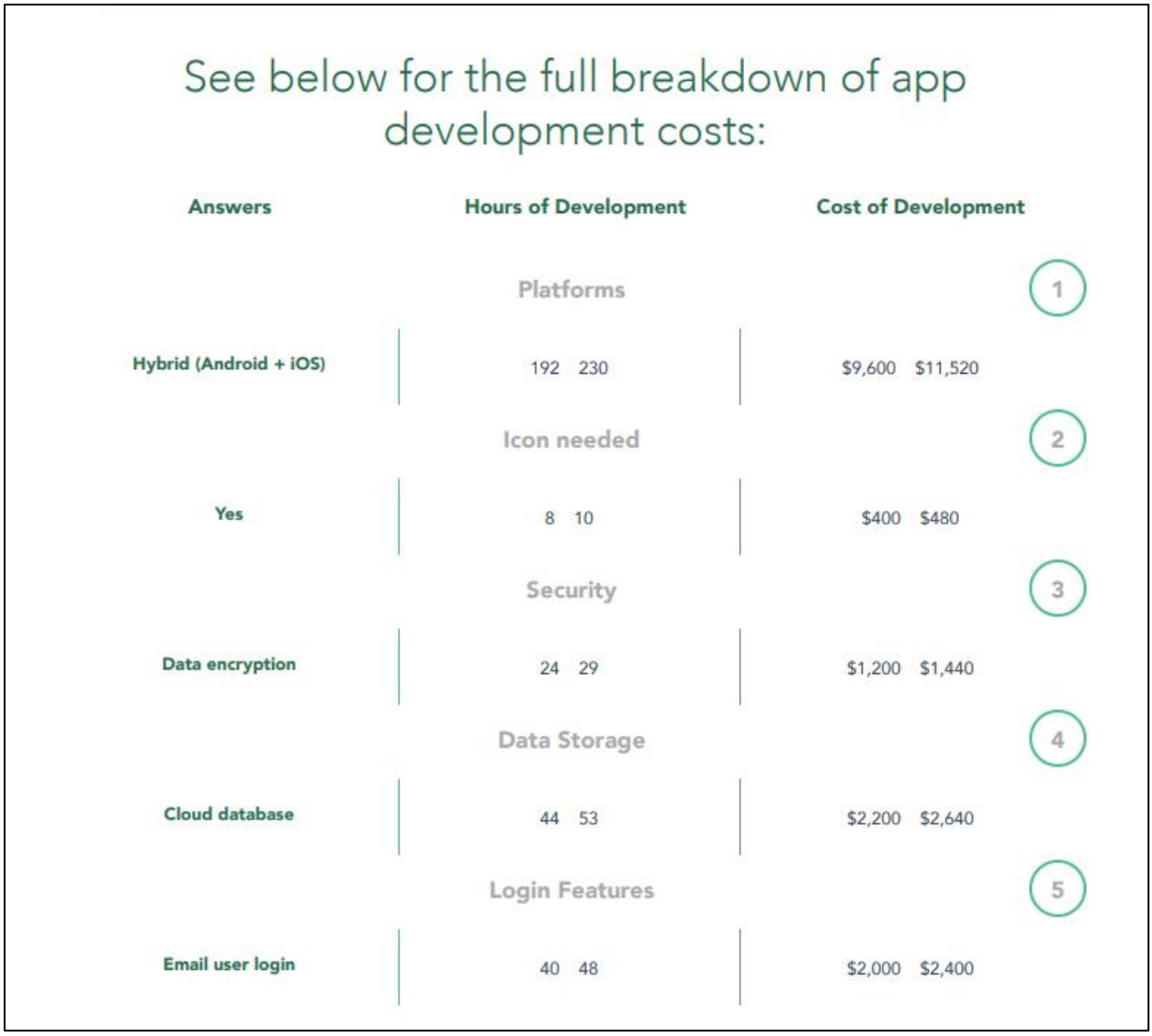
[4] R. Lakshmanan, "Over 4000 Android Apps Expose Users' Data via Misconfigured Firebase Databases," 12 May 2020. [Online]. Available: https://thehackernews.com/2020/05/android-firebase-database-security.html. [Accessed 26 March 2024].

[5] OpenAI, "Enterprise privacy at OpenAI," 10 January 2024. [Online]. Available: https://openai.com/enterprise-privacy. [Accessed 26 March 2024].

Appendix A. APP Cost Report

The following screenshots are from the app cost report provided by https://www.appdevelopmentcost.com. This calculator should be used again to estimate costs once the caregiver side and person with dementia side features are fully defined for an MVP of the FRED app.




See below for the full breakdown of app development costs:
Answers
Hours of Development
Cost of Development
Platforms
1
Hybrid (Android + iOS)
192 230
$9,600 $11,520
Icon needed
2
Yes
8 10
$400 $480
Security
3
Data encryption
24 29
$1,200 $1,440
Data Storage
4
Cloud database
44 53
$2,200 $2,640
Login Features
5
Email user login
40 48
$2,000 $2,400

Media Features			6
Audio playback	24 31	$1,200 $1,560	
Video playback	24 31	$1,200 $1,560	
Utility Features			7
Maps & Location	40 50	$2,000 $2,500	
Messaging	80 96	$4,000 $4,800	
Search bar	30 36	$1,500 $1,800	
User profiles	32 38	$1,600 $1,920	
Phone sensors usage	40 52	$2,000 $2,600	
UX Features			8
Push notifications	40 48	$2,000 $2,400	
SMS Messaging	80 96	$4,000 $4,800	
Sync between devices	50 70	$2,500 $3,500	
Activity feed	32 40	$1,600 $2,000	
General Features			9
In-app purchases	40 52	$2,000 $2,600	
Third Party Services			10
5 or more	300 405	$15,000 $20,250	


Admin Features
11
App analytics
56 67
$2,800 $3,360
Additional Features
12
N/A
Tablet Integration
13
Yes
1180 1509
$59,020 $75,465
Design Level
14
Custom
950
$47,481
Screens Amount
15
Average Users
16
50+
I'm not sure
566 778
$28,277 $38,895
Agile Process
17
Not selected
0
$0
Client Expertise
18
I have basic knowledge in the process of creating mobile apps
292 377
$14,610 $18,849
Modifiability
19
I have a solid idea of what I want to build but I need to define some specific features
584 754
$29,219 $37,698


App Testers
20
MVP level (minimum viable product)
190 245
$9,496 $12,252
Project Manager
21
I will need an external project manager (Recommended)
1235 2286
$61,726 $114,289
Web Version
22
No
0
$0
Total Hours of Development
6173 hours
8381 hours
Total Cost of Development
$308,629 USD
$419,059 USD

Appendix B. Unit and Integration Testing

Table 5 serves as a comprehensive guide to ensure the seamless integration of various components in the FRED app during software development. For each core component in gray, there are corresponding functions, user inputs, and expected outputs. For example, the component *Sudoku Game* has the function *User starts Sudoku game*. Then the user inputs *User clicks the Sudoku icon on the home page* and the expected output is *game start/settings page is displayed*.

Table 5: Integration Testing Table for FRED App

Sudoku Game		
Function	Input	Output
User starts Sudoku game		
	User clicks Sudoku icon on home page	game start/settings page is displayed
	User inputs level of difficulty	
	User hits start game button	game sudoku game board displayed
User plays game		
	Game board with empty sudoku board displayed to User	
	User inputs numbers	numbers are displayed on game board
Emergency Calling		
Function	Input	Output
User adds emergency contact		
	User clicks hamburger icon on home page	display sidebar menu
	User clicks add emergency contact button	display emergency contact setup page
	User inputs name, relationship, phone number	data is saved to the database
User makes emergency call		
	User clicks emergency call widget on home page	display tap and hold button page
	User holds button down for 5 seconds	phone call to emergency contact starts
	User holds button down for < 5 seconds	phone call to emergency contact does not start

AI FRED Chatbot		
Function	Input	Output
User wants to talk to FRED		
	User hits FRED Chat button on home page	display Fred avatar and greeting text
	User starts talking or types in text	user input is sent to ChatGPT
		display ChatGPT response to user
Task Manager		
Function	Input	Output
User adds reminder		
	User is in task manager	
	User clicks add reminder button	a form with fields popups
	User fills in data, time, note, and notification type	correct text is displayed in the form
	User hits save button	data is stored in the database
User receives a reminder		
	the time and date match a user task in database	note data is retrieved from database
		User gets notification
User checks off task		
	User is at home page	
	User clicks check box	task is removed from task manager icon
		is_done field is updated in database
Homepage		
Function	Input	Output
User wants to view homepage		
	User is logged-in	home page is displayed with all activities present
User wants to play a game		
	User clicks the play a game icon	the game selection page is displayed
User wants to enter task planner		
	User clicks the task manager icon	the task manager page is displayed
User wants to chat with FRED		

	User clicks the FRED chatbot icon	the chatbot page is displayed
User wants to make emergency call		
	User clicks emergency call button	tap and hold button page is displayed
User wants to logout		
	User clicks logout button	login page is displayed
Speech to Text		
Function	Input	Output
User wants to set reminder using voice controls		
	User holds down microphone button and says, "set medication reminder for 1:00pm tomorrow"	speech is recorded and processed
		reminder fields are stored in the database
User wants to make an emergency call using voice controls		
	User holds down microphone button and says, "make emergency call"	speech is recorded and processed
		emergency call is initiated to emergency contact
User Account		
Function	Input	Output
User can create new account		
	User at login page	
	User clicks button don't have an account button	register page is displayed
	User types in username, email, password, and confirm password	
	User hits register button	User is taken to the home page and user data is stored in database
User can login to account		
	User at login page	
	User enters email and password	
	User hits login button	home page is displayed

Memory Card Game		
Function	Input	Output
User starts memory card game		
	User clicks memory card game icon on home page	game start/settings page is displayed
	User inputs level of difficulty	
	User uploads custom photos	
	User hits start game button	game board is shown with custom photos on the cards
User plays game		
	Game board will cards facing up displayed to User	
	Cards flip over	
	User chooses a card	Card flips up
	User chooses second card	Card flips up
	Cards match	Add 1 to game score
	Cards do not match	flip both cards back over
	User finds all matches or time is up	game finished page is displayed with game score
		game score is stored into database

F.R.E.D.

Final Design Report Volume 3: Acceptance Test Results

April 15, 2024

Revised: 5/2/2024 11:39:00 PM Thursday, May 2, 2024

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List of Terms and Abbreviations

AI	Artificial Intelligence. A field of computer science focused on creating systems and machines that can perform tasks typically requiring human intelligence, such as learning, problem-solving, and decision-making.
API	Application Programming Interface. A software intermediary that allows two applications to talk to each other and share data within and across organizations.
ADRD	Alzheimer's Disease and Related Dementias. The broad range of neurodegenerative diseases fall under this category.
ISD	Interdisciplinary Senior Design. An educational program at the University of Tennessee where students work with companies to develop industrial and commercial prototypes.
MVP	Minimal Viable Product. A version of a product with just enough features to be usable by early customers who can then provide feedback for future product development.
UX/UI	User Experience / User Interface. User experience relates to how a user feels whenever they interact with a product or service. User interface refers to the touchpoints a person uses to engage with a digital product.
WCAG	Web Content Accessibility Guidelines. A set of guidelines from WebAIM for the graphic design of digital content to ensure visual differentiation is possible.
WebAIM	Web Accessibility in Mind. A website built to provide resources to develop accessible web content.
UT	University of Tennessee. A university in Knoxville Tennessee offering the course that assigned this report's project.

1. Introduction

This section presents an in-depth exploration of acceptance testing for product specifications, centering on the evaluation of the FRED app design through user testing and feedback, alongside internal assessments for speed and reliability. Emphasizing the importance of quality assurance, this phase aims to ensure that the FRED app aligns with predefined targets outlined in the product specifications. A summary table is provided, offering a concise overview of key metrics including product specification details, corresponding acceptance tests, and resulting outcomes. This comprehensive approach underscores NOVI's commitment to delivering a product that meets client and user expectations.

1.1 Acceptance Testing for Specifications

Acceptance testing correlates with the specifications outlined by the project stakeholders in volume 2 of the NOVI final design report. Some specifications required multiple tests to fully understand the state of the project concerning meeting requirements. The original scope of work and solution to the project only included a person with dementia (PWD) view of the application. For this reason, the tests outline here only relate to the PWD side of the app. Some aspects of tests can translate between the specifications for the PWD side and future specifications for the caregiver side of the app. Limitations of development and time this semester did not allow every test in this volume to be performed during the ISD course. These tests are still outlined with the process and expected data for future work on the project to reference. Table 1 lists the testing that NOVI performed during the semester. This table includes the test number, the specification being tested, and a brief description of the test along with the target value and result. General target values were determined in the specifications of volume 2 of this report. A complete list of tests and results is included in Appendix A. Complete List of Acceptance Tasting This will include the tests not performed during the semester. Subsequent sections of this volume will outline the testing procedures and results. One specification, S07 Advertising, was not included in testing. This is due to the inability to valuably test this without fully forming the future of the project.

Table 1: List of acceptance tests performed during the ISD course with specification, target, and result.

Test No.	Product Specification	Acceptance Test	Target	Result
Test 2	S02 User Feedback: caregiver feedback	Surveying caregivers on UI elements.	>80% average rating	Pass - Conditional
Test 3	S02 User Feedback: demo feedback	Surveying UT affiliated students and staff on prototype experience.	>80% average rating	Fail
Test 4	S02 User Feedback: PWD user feedback	Surveying PWDs on their experience with complete MVP application	>80% average rating	Pass
Test 7	S05 Loading time: App Connectivity	Ensuring the application does not crash on launch or when accessing features	Use all features in the app in a randomly generated order 5 times without restarting the application.	Pass
Test 8	S05 Loading/Lag Time: Startup Loading time	App loading time and connectivity to login page through Firebase	< 3 seconds	Pass
Test 9	S05 Loading time: App Connectivity	App loading of internal memory timed and below particular threshold	< 1 second	Pass
Test 10	S05 Loading time: ChatGPT and Open AI Connectivity	API call to Open AI's Whisper and ChatGPT models for speech to text load time	< 1 second	Pass
Test 11	S06 Vulnerability assessment	Test app through QARK for security	High safety score	Fail
Test 15	S11 Typeface	Show positive results from survey data on typeface	>90% accuracy	Fail
Test 16	S12 Color contrast	Use WebAIM contrast checker on app's adjacent colors	Pass WCAG AA and WCAG AAA standards	Pass - Conditional

2. Test Procedures and Results

In this section, NOVI presents a comprehensive overview of the test procedures and results conducted on the FRED app, building upon each of the acceptance tests outlined in the previous section. The procedure for each test is presented alongside a data summary, capturing the findings

and observations derived from the testing process. Following the data summary, an interpretation of the results is provided, offering insights into the performance and functionality of the FRED app. Additionally, recommendations are outlined, including any results obtained from root cause analysis conducted to identify problem resolutions. This section aims to provide a thorough analysis of the test procedures and results, informing future development and optimization efforts for the FRED app. Tests that are not performed will be indicated in the description by the label “untested.” Refer to Table 1 for a list of tests that have results done for this year's project.

2.1 Test 1: Task Completion Rate (Untested)

The task completion test will judge how usable the app is through user completion of tasks within features. Due to development progress, this test will not be completed this year, but will be included as a recommendation for moving forward in accepting a more complete final application for distribution. The importance of this test is to improve app usability and accessibility. Failure in this test would mean that aspects of the user interface and user experience will need to be altered to be more intuitive.

2.1.1 Procedure

The first step is to procure 3 groups of users. The first will be fellow students, the second will be elderly individuals and adults, and the third group will be PWDs. Ideally, these groups are selected to provide extensive feedback across demographics. Since the app is currently being designed by individuals in their early 20s, some aspects of the user experience may be more obvious or less obvious to certain groups based on their age. It is a fact that younger individuals may be more acclimated to using a new application and understanding the flow of the app without the need for assistance. The younger individuals are more accessible than the other demographics and can point out clear faults in the application through their failure or success in this test. The older individuals and PWDs will act more for validation, ensuring that the demographic being catered to can use the app without assistance. During this test, users will be given a task within the app such as setting a reminder and finding a reminder, which is to be completed with minimal help. Ideally, the testers would include all features of the app in the test. For this example, Measurement will include only pass-fail metrics which are determined by completing the task successfully or not. Table 2 shows the tasks that could be performed with the features included in the final NOVI prototype. The list of tasks for a model trial of the current FRED setup is listed in Table 2 with the task and related features. This also includes passing criteria for the trial.

Table 2: Example list of tasks during user testing with passing criteria and related features.

Trial Task	Passing Criteria	Feature
Set a reminder for 9 am, one week from today.	User set a reminder for April 22 at 9 am.	Task Planner
Set a reminder for 2 minutes from now. Description “Trial Complete”	User was able to get a reminder that says task complete about 2 minutes after trial.	Task Planner
Find a reminder set for the first week of next month.	User has a reminder set for any time between May 1-4.	Task Planner
Open the Sudoku game and play for 3 minutes.	User was able to open the sudoku game and insert at least 3 numbers. Repeated insertion of numbers after deleting the previous try will count.	Games
Open the memory card game and complete a full round.	User was able to open and complete the card game.	Games
Ask FRED for a recipe for 3 different dishes (breakfast, lunch, dinner)	User was able to open chat and communicate the request. 3 dishes for each time of day should be acquired.	FRED chatbot

Depending on the total number of features, each user should be given a set of 5 randomly generated tasks from the full list of tasks. This can be generated by different methods depending on preference. Figure 1 shows a sample of the Excel function that may be used to generate this for a group of 10 individuals. The individuals in the younger group would be given 3 minutes to complete the task with any time over that 3-minute mark being considered a failed trial. individuals in the older groups will not be timed but will be allowed to go until they ask for help or decide to stop the trial. For both groups, the games will not be timed and scores on the game will not be considered. The Excel formula that can be used to generate this list is:

=CHOOSE(RANDBETWEEN(1, 7), "Task 1","Task 2","Task 3","Task 4","Task 5", "Task 6", "Task 7") (1)

User #	Tasks for User					List of Tasks
1	Task 3	Task 5	Task 2	Task 5	Task 4	Task 1
2	Task 7	Task 6	Task 5	Task 4	Task 7	Task 2
3	Task 4	Task 7	Task 5	Task 7	Task 1	Task 3
4	Task 7	Task 2	Task 3	Task 4	Task 1	Task 4
5	Task 1	Task 6	Task 2	Task 4	Task 4	Task 5
6	Task 4	Task 4	Task 4	Task 7	Task 5	Task 6
7	Task 3	Task 6	Task 6	Task 4	Task 7	Task 7
8	Task 2	Task 1	Task 1	Task 7	Task 4	
9	Task 5	Task 5	Task 1	Task 1	Task 4	
10	Task 7	Task 7	Task 2	Task 2	Task 4	

Figure 1: Random list generator in Excel for determining tasks to be completed by users.

2.1.2 **Data Summary**

The tasks completed will be added together and divided by the product of the total number of individuals times 5 for the total number of tasks completed. This is an example of the equation that could be used.

$$\%\ for\ group\ in\ task\ number = \frac{(tasks\ completed\ by\ group\ for\ task\ number)}{(users\ in\ group) * 5} \qquad (2)$$

Those values can be displayed in a bar chart showing each of the tasks with the percentage completed by each testing group. Additional data would be provided through verbal and written reviews of the experience. The data is simulated in this test to show how results may be viewed by the team. Figure 2 shows an example of how those results might be displayed. This bar chart shows three testing groups labeled by color and groups based on task. The left-hand side is the percentage value of tasks. In this sample, the individuals from the younger group performed higher overall tasks than the older group and the PWD group.

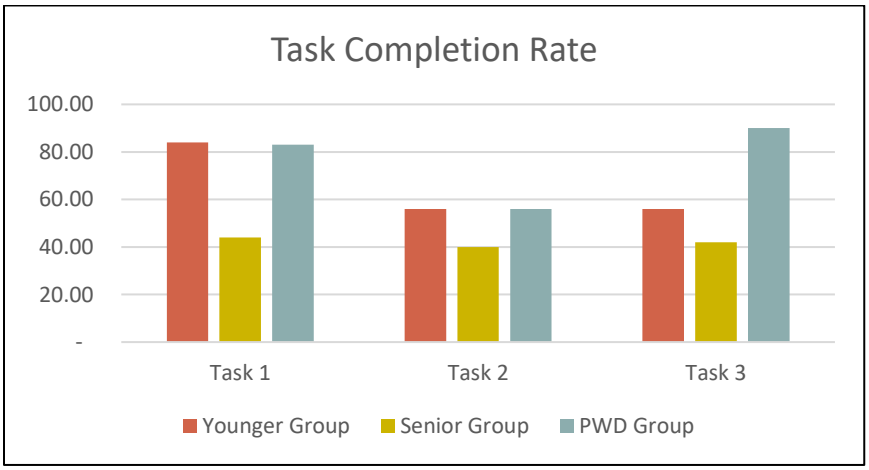


Figure 2: Example of task completion rate chart.

2.1.3 Interpretation of Results

The goal of this test is to have greater than 90% completion for each testing group. In the example data the groups fail to reach that value, which would mean the specification for task completion rate would fail to meet customer requirements. As an alternative method of analyzing the results, the additional testing groups of seniors and students can also be set as standards to compare the PWD group to. In this case, it would be ideal to have the PWD group score within 5% of the average between the other two groups. This result would indicate that the app is performing well in its desired population while showing if the focus of development should be on fundamental aspects of the app or dementia-specific accessibility aspects.

2.1.4 Recommendations

This testing method would best be implemented with a complete application and judges how intuitive the UI is. There is additional testing for games in this report so tasks relating to that feature may just include opening, completing, and closing the game rather than score within the game. As the app develops it is suggested to make the tasks more complex and integrate different tasks into a single process.

2.2 Test 2: Caregiver Feedback Survey

This test was a survey sent to caregivers that covered details of the user interface and user experience judging the viability of the features as well as initial design aspects. This is the only test that is specified for the caregiver side of the application and is included to improve preliminary outlines for future design. Caregiver input is not only important for furthering the caregiver side of the app to improve its usability but also for improving the interactions between the caregiver side and the PWD side of the app for seamless integration. This test surveys what caregivers want and what they like from the NOVI team’s current design based on information from previous interactions.

2.2.1 Procedure

The team wrote a survey to caregivers that included 12 questions:

1. What apps have you used to make your life easier regarding caring for someone with dementia?
2. If you choose "other" on the previous question, please specify the apps you use below.
3. What apps has your loved one with dementia used in the past?
4. If you choose "other" on the previous question, please specify the apps they have used below.
5. What do you struggle with the most when caring for someone with dementia?
6. If you chose other on the previous question, please specify.
7. Please state the likelihood of trying a new app that is geared toward helping caregivers of dementia patients.

8. If you were to use this new app for caregivers, what features would you want it to have?
9. Please rank how visually appealing you find this color pallet.
10. Would you encourage your loved ones in the early stage of dementia to use an app designed to help their cognitive function, social engagement, and organization?
11. If your profile on the app was linked to your loved ones, what would you like to see?
12. The following two pictures are potential logos for our FRED app. Please state which logo you like the most.

The survey is distributed via email and is linked as a Google Forms document. Appendix B includes the actual Google form used. Both informal and formal caregivers were surveyed, but this was not factored into the results of their responses. Google Forms provides the data desired from this test depending on the question asked. The team also attended a caregiver meeting with a group from Maryville, TN who provided verbal input on what a caregiver needs in day-to-day life. This verbal input is not included in testing results but is still considered for development purposes.

2.2.2 **Data Summary**

Quantitative and qualitative data was acquired from this survey. The team only received 7 responses to the survey in total at the time of writing. The data for the responses is shown here. Figure 3 shows the responses for question 1 in a columned chart. The columns are apps that caregivers have used in caring for someone with dementia. The columns are sized by the number of people who selected the app. Only one app listed, MediSafe, was selected as previously used with all of responses selecting “other”.

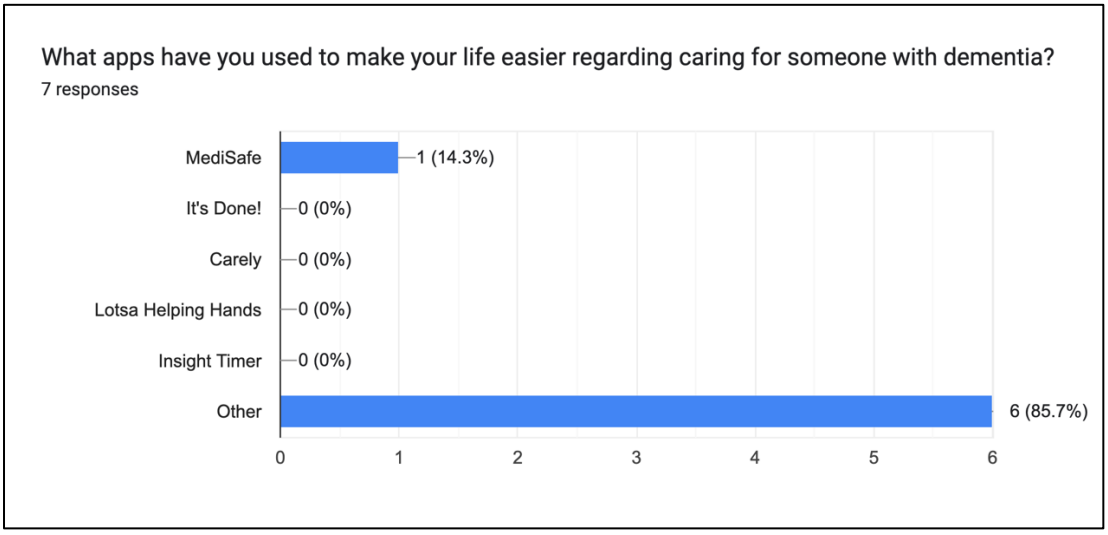


Figure 3: Results for question 1 from the caregiver survey are shown as a column chart with accumulating values based on columns representing an application used.

Figure 4 shows apps that the caregivers say their PWD has used in the past. Like Figure 3, the columns represent a dementia care app with the values in the columns being responses from the caregivers, indicating usage of the app. Lumosity is the only app from this sample that had multiple users. During conversations with the caregivers, the team found that even those who have used the app in the past found it to only have a temporary interest for them.

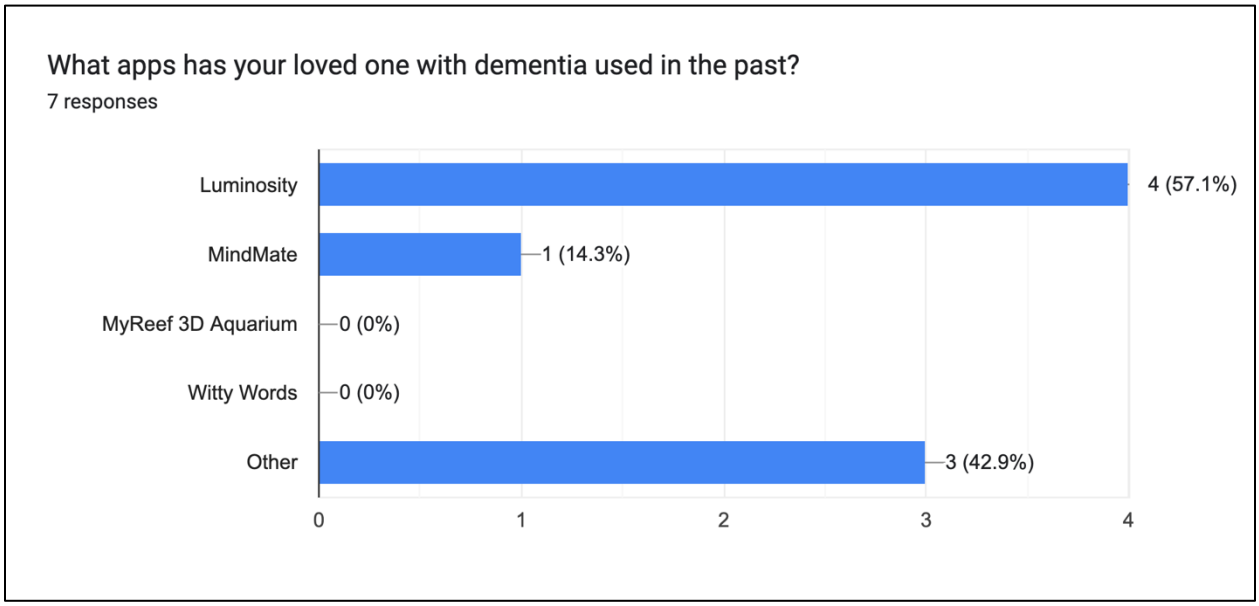


Figure 4: Column chart for question 3 showing caregiver-reported usage of apps by PWD

Data from question 5 gives information on what caregivers feel is the most challenging in their care for the PWD. All 7 responses selected mental/emotional strain as what they struggle with the most. Figure 5 shows the chart of responses, with the topics of struggle listed to the right.

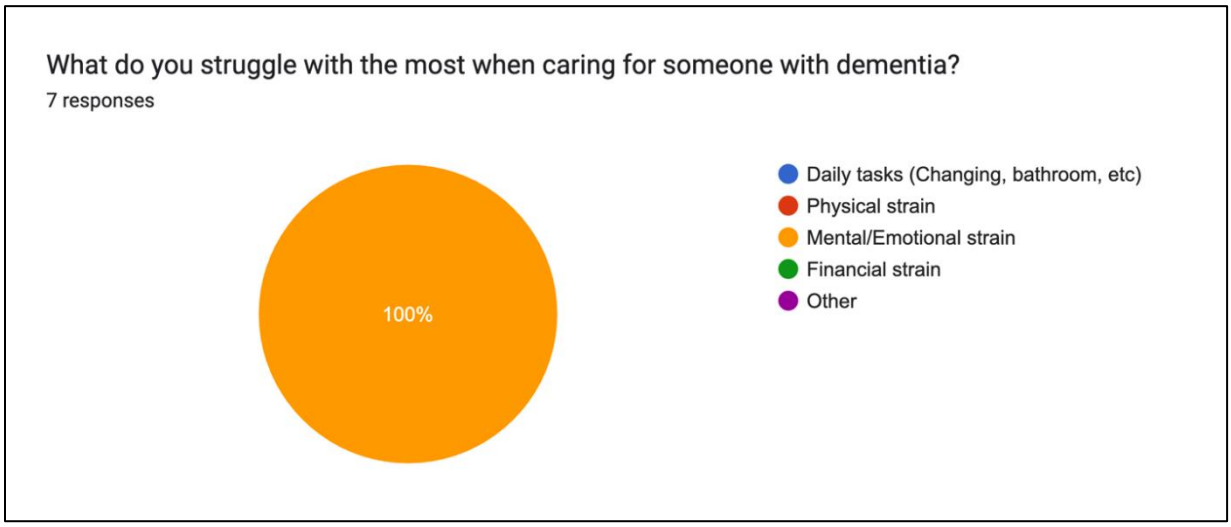


Figure 5: Chart of responses to what caregivers struggle with the most.

The likelihood of caregivers using a new application that is designed for dementia care is shown in Figure 6. On this chart, the lowest value (1) indicated very unlikely while the highest value 5 represented highly likely. The columns are stacked by the number of responses. The average of the chart was 3.57 indicating the overall opinion on the app was between neutral and likely.

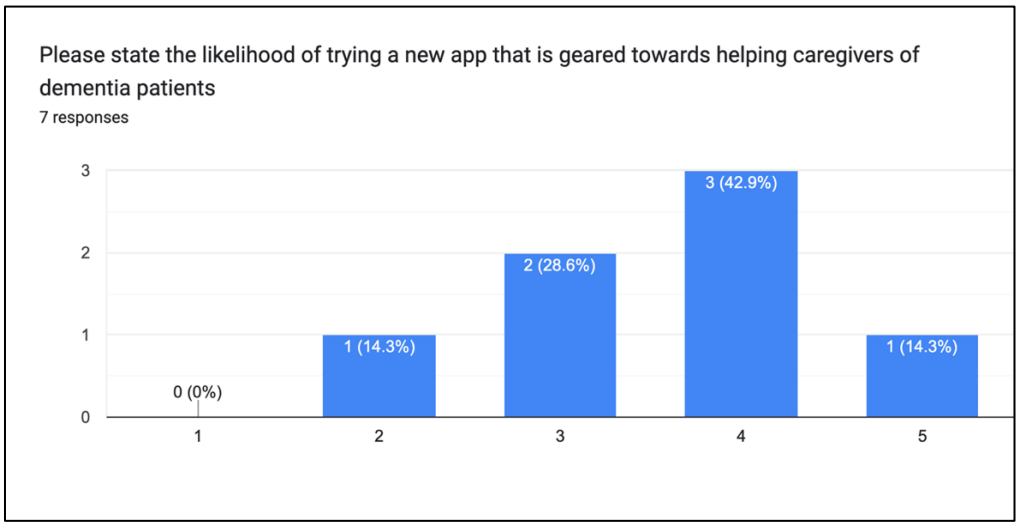


Figure 6: Likelihood of caregivers using new app for dementia-care assistance.

The data from Figure 7 shows the features that caregivers felt would be most desirable in an app for dementia care. The 7 responses were allowed to select multiple features. The left side of the chart lists the features that could be selected while the columns are stacked with the number of selections. Four features were selected by 6 or more caregivers with only the AI chatbot receiving no selections.

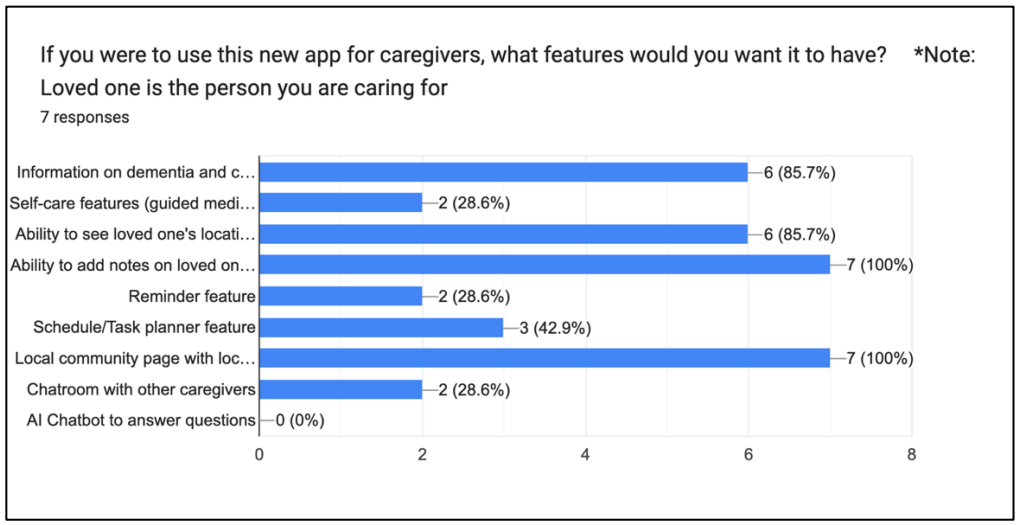


Figure 7: Most desired features of the FRED app for caregivers.

The color pallet selected for the caregiver side was changed slightly from the PWD side of the app for a more professional look. Question 9 showed caregivers this color pallet and allowed them to rate how appealing they found it. Figure 8 shows the results for this as 1-5 ratings. Columns contain the number of responses for the rating. The lower value 1 indicated it was ugly or very unappealing while the higher value 5 indicated they found it very appealing. Results showed an overall lack of attractiveness for the color pallet with an average value of 2.43 selected. This is between unappealing and neutral.

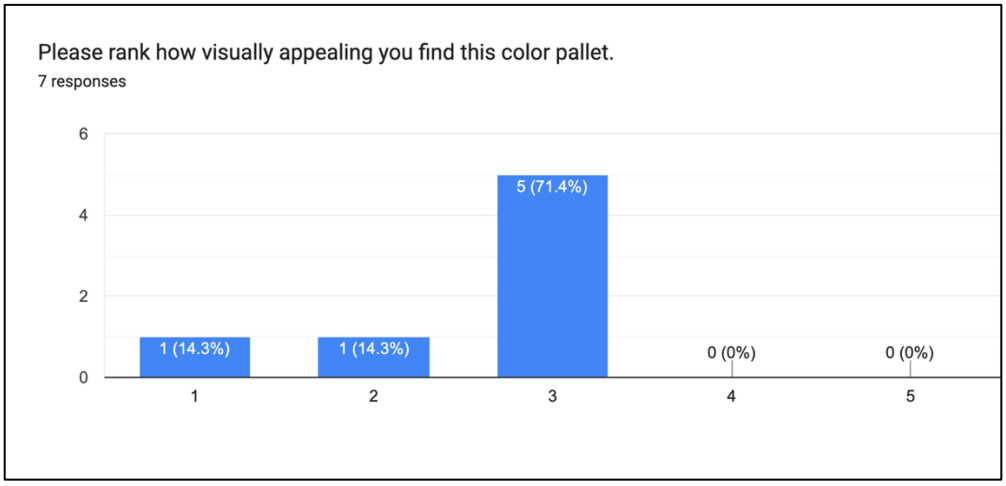


Figure 8: Ratings for the attractiveness of the color pallet for caregivers.

Responses for question 10 are shown in Figure 9. The results show that 6 out of 7 responses would maybe encourage the use of a PWD app for someone in the early stages of dementia. In the chart,

the responses to maybe are shown in orange while the responses to yes are shown in blue. A legend is shown to the right of the chart.

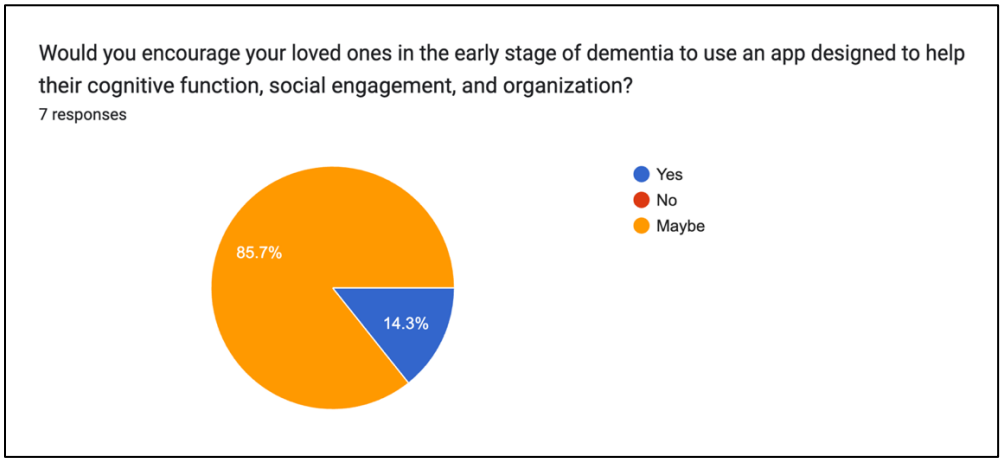


Figure 9: How likely are caregivers to suggest an app for a PWD to someone in the early stages of dementia.

The NOVI team developed two possible features to be included in the caregiver application: tasks the PWD has completed on their own and the location of the PWD. The responses to question 11 are asked non-comparative preference of the two features. The bar chart in Figure 10 shows the responses who would like to see each feature in the application with all responses wanting location to be an included feature.

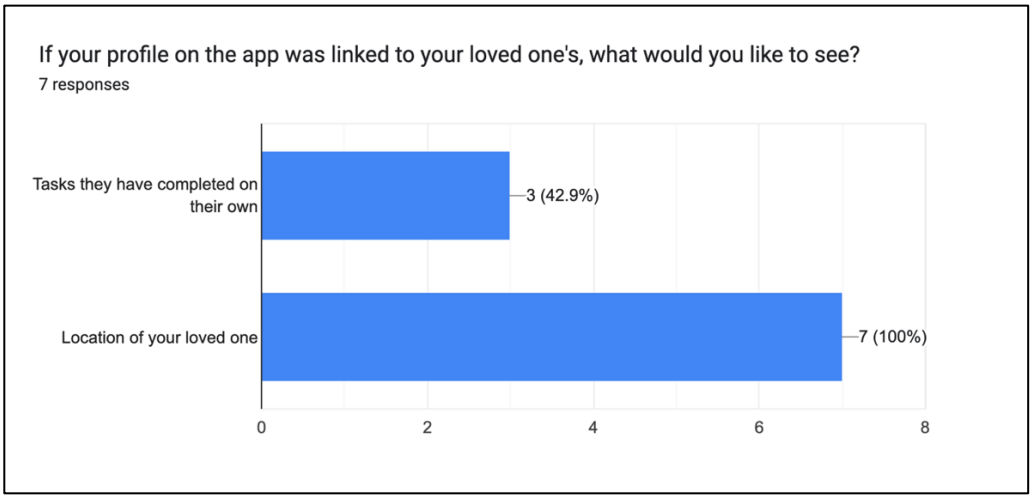


Figure 10: Preference of app features for 2 currently planned features.

Question 12 regarding the preferred mascot for the FRED app produced A or B results showing the preference in a pie chart. Option A is the newer model of the FRED mascot while option B is the older model. These can be seen in the survey posted in Appendix B. Figure 11 shows the pie chart for this question with most responses preferring option B (71.4%) to option A (28.6%).

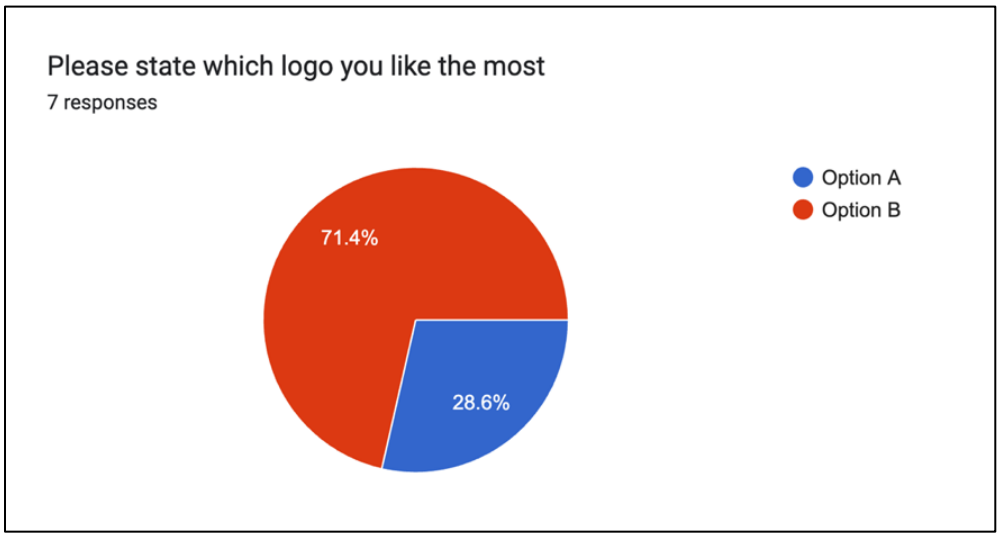


Figure 11: Comparative preference of current app mascots/logos.

2.2.3 **Interpretation of Results**

The data obtained from this survey is insightful to the direction the caregiver app should go. Initial results from the preliminary design aspects show improvement needed for the scope of the application. The responses for previous apps used showed that many of the caregivers do not use apps at all for dementia-related care. From Figure 3, four of the six responses for “other” said that they do not or have not used mobile applications. From Figure 4, two of the three responses for “other” also said that applications were not used. What was interesting was the number of caregivers who have used Lumosity with their PWD. This may show that games and cognitively stimulating activity are something that PWDs and caregivers find attractive or useful. Despite the seemingly low overall usage of mobile applications, figure 4 demonstrates that applications may still be desired and used by caregivers if made desirable for caregivers. The responses show that 85.8% of the caregivers are neutral to highly likely to use a mobile application geared towards helping the ADRD community specifically. 57.2% are likely to highly likely to try that app.

Regarding the features and scope of the app, figure 3 shows that emotional stress and mental strain are the largest issues faced by caregivers. This is further supported by the data from Figure 7, showing that information, notes, location, and a community access point are the most desirable features in an application for caregivers.

The data from this survey is not effective in determining if the specifications for user feedback are met but ensures that there is a growing wealth of information as to which direction development should go. Knowledge such as this was not specified through the customer requirements but is part of the scope of work to make progress toward a minimum viable product. With such results, the test does meet the requirements to be valid as a passed test.

2.2.4 Recommendations

The caregiver test can be improved to become more of a user testing of the caregiver application, and this will improve results from this test. This will depend on the direction of future development. To improve this survey based on the status of the test, including more caregiver groups can help improve the responses received. The team was only able to access one caregiver group which is part of the response for low response numbers. Increasing the number of caregivers will also allow for more representative data since the single group tested was contained to a small city. The app is meant to cater to caregivers across the country, therefore input from caregivers should not be limited to such a small collection of responses from a single area.

2.3 Test 3: UT Student and Staff Survey

This test has been performed with UT students and staff as a survey on the MVP2 prototype demonstration. The goal was to engage a critical audience of peers to determine the status of the application and generate ideas for clear faults in the design. This test was performed as user testing with a survey afterward to record opinions on the trial.

2.3.1 Procedure

The team gave a 7-minute presentation on the prototype design of the PWD side of the application including a short video demonstration of features. After the presentation, users were given reading glasses and gloves to simulate some of the difficulties in sight and touch that elderly people experience with technology. Users were given 1-3 minutes with the prototype application on an Android phone, free to use the set reminder and chatbot features as well as explore the UI. For this test, the features were somewhat limited due to changes needing to be made to the backend code of the app. Features such as the games were visible but not accessible. After using the app, the team distributed a QR code that was linked to a Google Forms survey of their experience and their recommendations. Users were asked to use their phones to scan the QR code and complete the survey. The following questions were asked:

1. What is your approximate age?
2. How often do you use your phone for tasks other than calls?
3. Please rate your overall experience on the app.
4. What was your least favorite feature?
5. What was your favorite feature?

6. What feature do you feel is missing?
7. Please rate the attractiveness of the layout/design of the app.
8. Please rate the attractiveness of the color scheme of the app.
9. Please rate this feature independently: Task Planner
10. Please rate this feature independently: Reminders
11. Please rate this feature independently: Games
12. Please rate this feature independently: AI Chatbot
13. How likely would you recommend a similar app to an elderly individual or their family?
14. Do you wear glasses?
15. Please rate our new FRED avatar!

2.3.2 **Data Summary**

Users were asked to rate many features and designs on the application on a scale of 1-10. Users gave qualitative responses on their favorite and least favorite aspects of the application. Users also gave verbal critiques of the UI and UX which the team noted. Only 4 users gave responses through the survey which limited the data acquired from this test. The team included some questions that may have been more relevant with more responses, but with the low response outcome, the questions are not considered to be impactful for this report. Some of the responses still have valuable representation of major points for continued development. For the summary of data, the team is focusing on questions regarding design and experience. Figure 12 shows the rating for the overall experience that users had on the application. This is in the form of a rating from 1 to 10 with 1 being the worst experience and 10 being the best experience. An average rating of 5.25 was seen for this question indicating a generally neutral experience in the app.

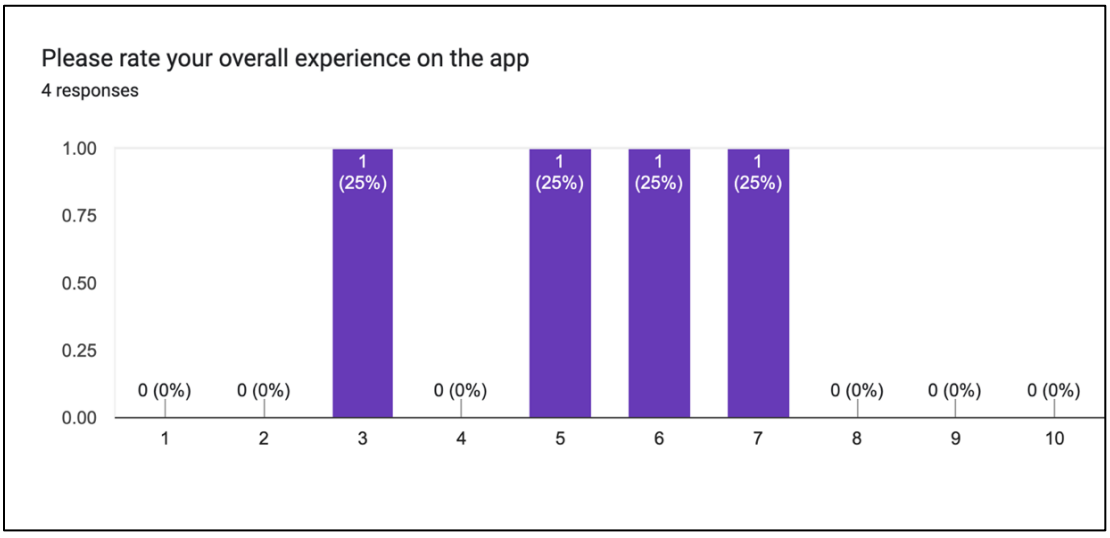


Figure 12: Ratings for the overall experience during the user's test.

The attractiveness of the app is represented by the data in Figure 13. A 1 to 10 rating was given with 10 being the most attractive. This produced an average of 7.5 indicating the user interface is relatively attractive to the users. Values in this chart range from 6 to 9.

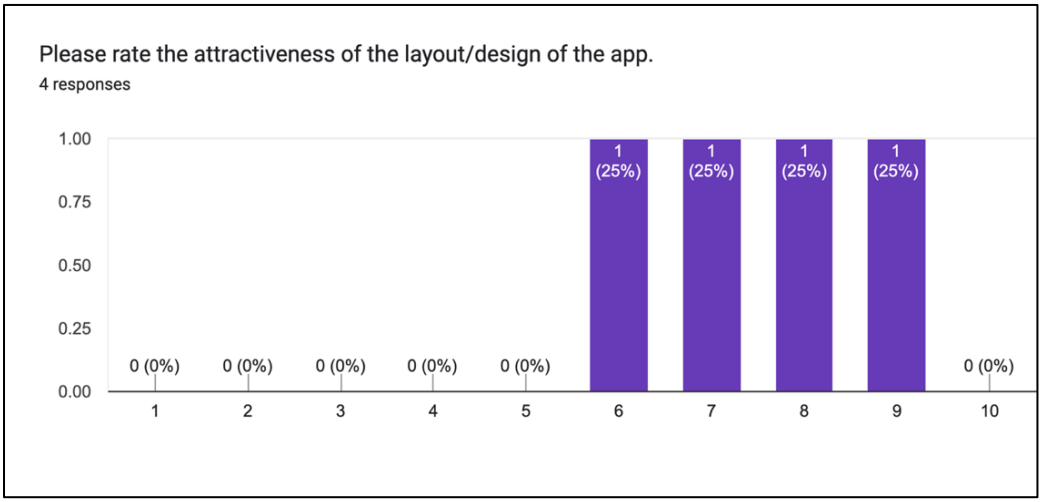


Figure 13: Ratings from user survey for layout/design of the demo application.

Data like that from Figure 13 was seen in the responses to question 8. Figure 14 shows these results with the same average value (7.5) and the same range of values (6-9). Opinions on the color scheme were generally positive.

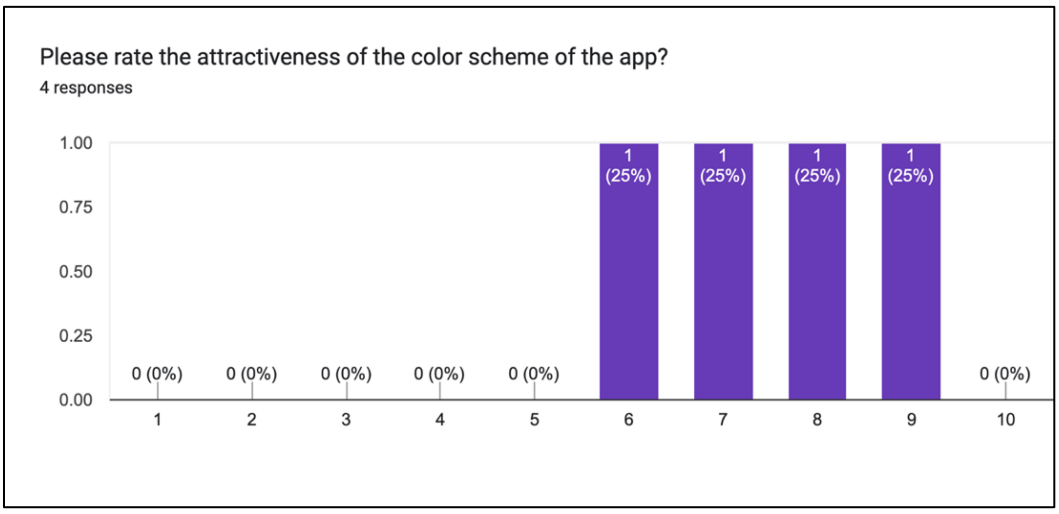


Figure 14: Ratings for the color scheme of the PWD app.

Not listed as quantitative data are some of the verbal responses received for the user testing experience. Many users noted issues with the text size. This was most prominent in the reminders and the AI chatbot. Users who interacted with the chatbot also noted some limitations in its capability. One of these responses mentioned that the chatbot is not able to recall information from past conversations.

2.3.3 Interpretation of Results

The lack of responses makes the results of this test have minimal impact on the project direction. What is of concern from the results is the relatively poor experience users seemed to report on their app test. This means that there are clear revisions needed for the prototype. A common response was on the inadequate text size. Users found it legible but those with glasses seemed to have more difficulty in reading the text for the chat and the reminders features. Test 15 analyzes text accessibility and will need to improve results to address these issues.

Users were not able to access all developed features, such as the game features, which limited the survey's practicality. Each feature was individually rated but without the ability to use these features fully, the results are not reasonably valid. Appendix B contains the full survey and results from it.

A passing grade was determined to be a rating of 80%, or 8/10 based on specifications previously outlined. This test did not meet the results desired from the specification based on the few responses gained from the test. For that reason, it is designated as failing the requirements for the specification.

2.3.4 Recommendations

Many users responded verbally and did not use the survey provided. This may have been due to an inadequate push by the team to get the responses. This may have also been improved by using a written survey rather than a digital one. When using the digital one, the team most likely would have received more responses by providing a platform other than the user's phone, such as a laptop or tablet.

The questions in the survey can be improved to reflect more detailed responses to the features and the experience. The survey included questions regarding age and if the user wears glasses, which can provide additional context on what the user experienced during the trial. More questions in this style can improve the quality of the feedback.

The users were given gloves and reading glasses to simulate some common issues senior individuals have with technology. This was somewhat effective, but the conditions for this may be able to be made more extreme or realistic with better equipment. This equipment could also be more specific to the user being tested at the time. This trial used the same glasses and same-size gloves for all individuals.

2.4 **Test 4: PWD User Feedback Survey**

This survey is intended to be given to people with early-stage ADRD after interacting with the FRED app after a specified period. It is designed to ask users about their overall experience using the app, spanning colors, text size, and ease of use. Due to issues of reaching this demographic, the test was instead performed with elderly individuals at a local senior center.

2.4.1 **Procedure**

Users were given the FRED app loaded onto a mobile device (Samsung Galaxy S8). They were asked to use the app for 5-10 minutes and go through each feature. The team member testing gave some guidance as to what the features did and how to access them. After using the app, the test group was asked to complete a Google Forms survey with the following questions:

1. How often do you use your phone for tasks other than calls?
2. Do you wear glasses?
3. Can you rate the overall attractiveness of the app?
4. Can you rate the color scheme of the app?
5. Please rate your overall experience on the app.
6. What was your least favorite feature?
7. What was your favorite feature?
8. Please rate this feature independently: Task Planner
9. Please rate this feature independently: Reminders
10. Please rate this feature independently: Games
11. Please rate this feature independently: AI Chatbot
12. If you were to design an app for a person with dementia, what features would you include that are not on here?
13. How likely would you recommend a similar app to an elderly individual or their family?
14. Do you wear glasses?
15. Please rate our new FRED avatar!

2.4.2 **Data summary**

Through this survey, NOVI aimed to collect a diverse range of data types to better understand the needs and preferences of people with ADRD. Google Forms will provide quantitative data, including ratings and Likert scale responses. Additionally, there will be qualitative data from open-ended responses, which will provide more detailed insight into user experiences. Some users provided verbal feedback that will be incorporated into these results. In the bar charts shown, the numbers correspond to indicative ratings with 1 being low and 10 being high. In cases where the Likert scale is used, 5 is a neutral value with 1 and 10 corresponding to extreme values. Users who responded primarily indicated normal phone usage of 2-6 hours a day as shown in Figure 15. Of the users, one did indicate that they only used a flip phone. This user did not provide any feedback

through the survey and did not try the app. There was a conversation that showed an aversion to newer technology due to a lack of practicality in their life. The information gathered showed some indication that a caregiver might find the caregiver version of the app useful for keeping up with that user, despite not getting much direct data because of a lack high high-functioning technology.

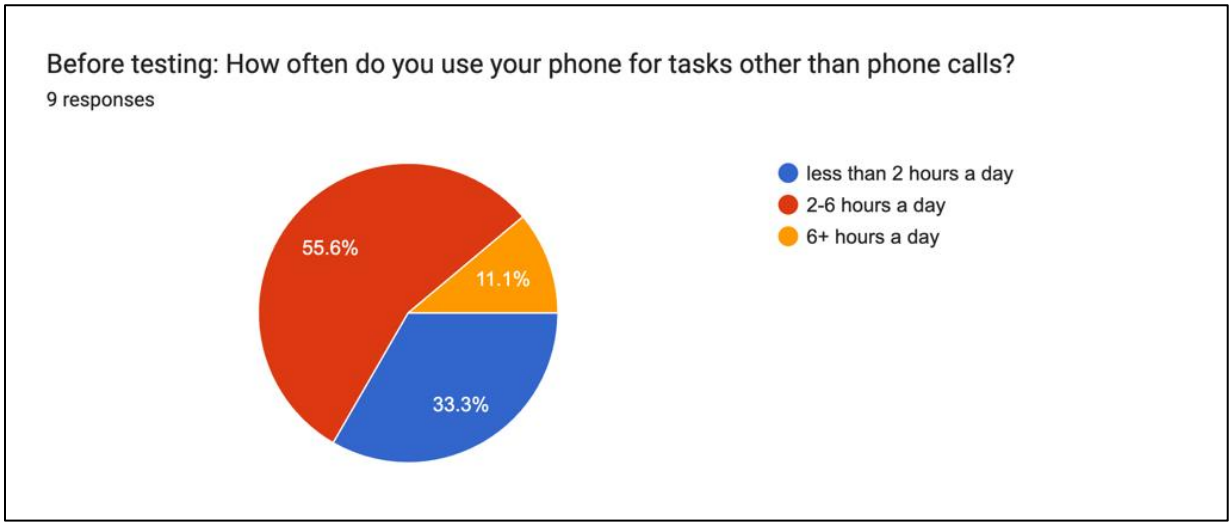


Figure 15: Pie chart of phone use in hours by users.

Users found the app attractive overall and attractive through the color scheme. Reporting for overall attractiveness showed favor in the attractive to very attractive range with an average value of 8.11 out of 10. The color scheme generated an average value of 8.11 as well. The results for the overall attractiveness are shown in Figure 16 and the results for the color scheme are shown in Figure 17.

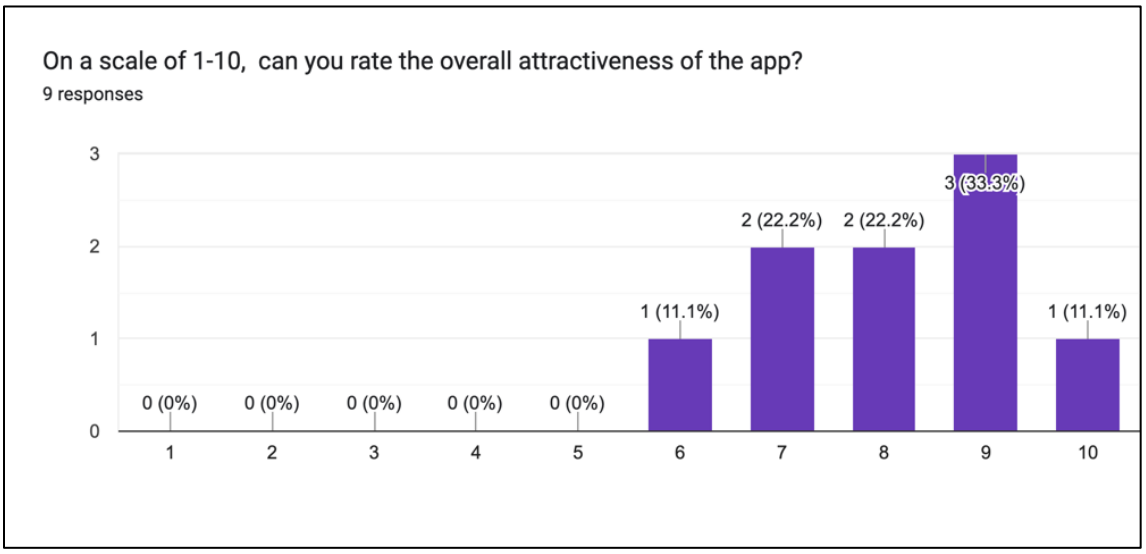


Figure 16: Results for overall attractiveness of the app for user testing.

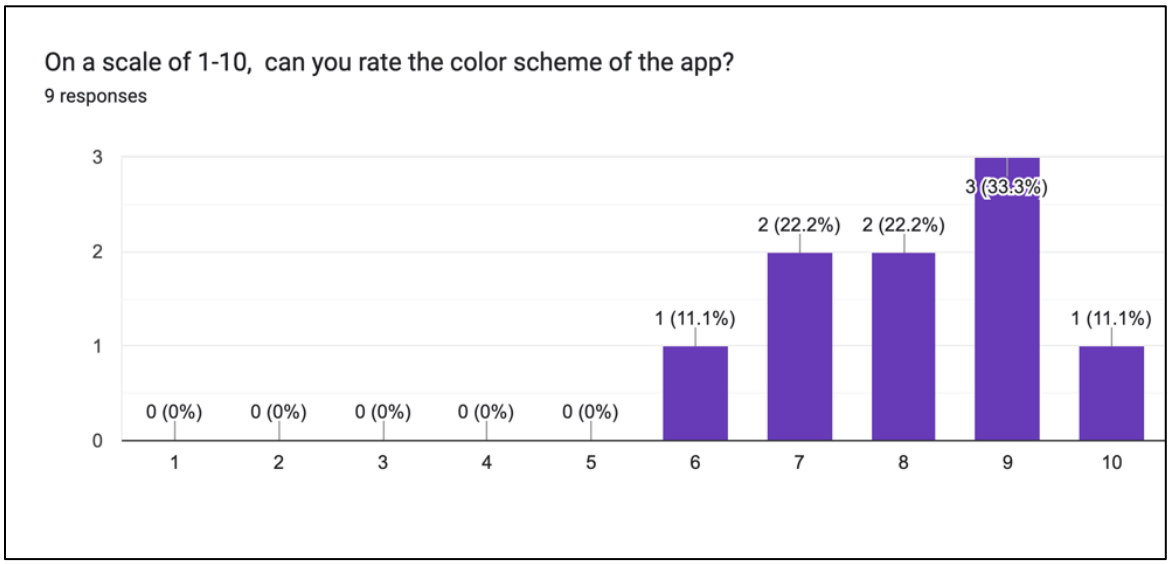


Figure 17: Bar chart for color scheme attractiveness.

For overall experience, users reported a wider range of responses. The average experience was rated at 7.11, which can be equated to a good experience. With this reporting, only one user reported below the neutral range with a rating of 3 out of 10. 66.6% of users fell in the good to very good range with ratings of 7 or higher. Figure 18 shows a bar chart of these results.

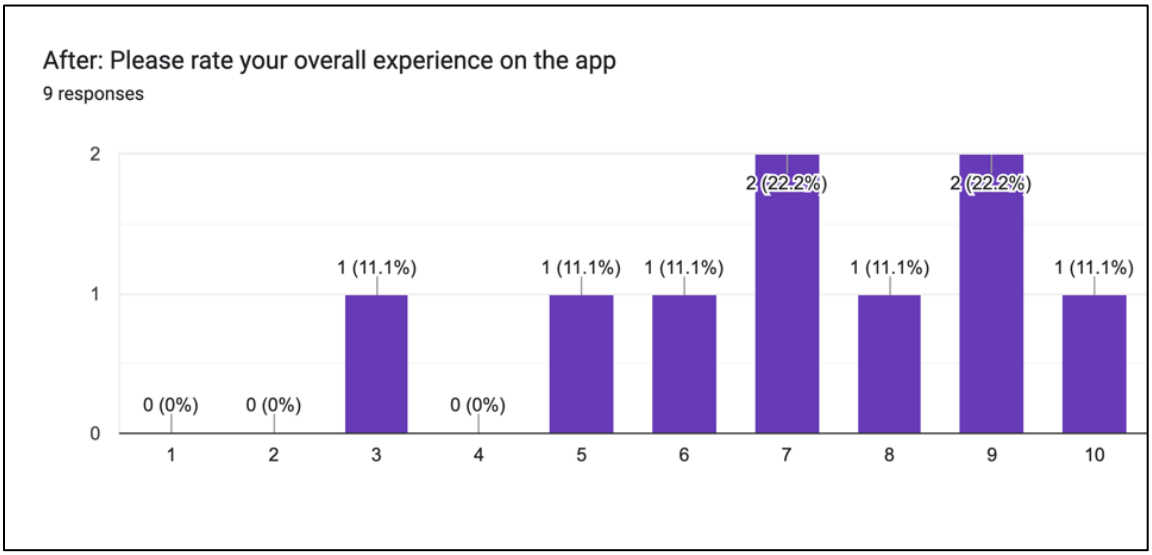


Figure 18: Overall experience rated by users.

Asking about the favorite feature on the app did not generate valuable results. The reporting of favorite and least favorite had the same values for each feature. Figure 19 shows the least favorite feature pie chart and Figure 20 shows the favorite feature pie chart. For the games feature 44.4% of users responded with it being their least favorite feature and 33.3% responded with it being their favorite feature. For the reminders feature, 22.2% reported it being their least favorite and 33.3% reported it being their favorite feature. For the task planner, 22.2% reported it being their least favorite feature and 11.1% reported it as their favorite feature. The AI chatbot reported 11.1% as the least favorite feature with 22.2% as the favorite feature.

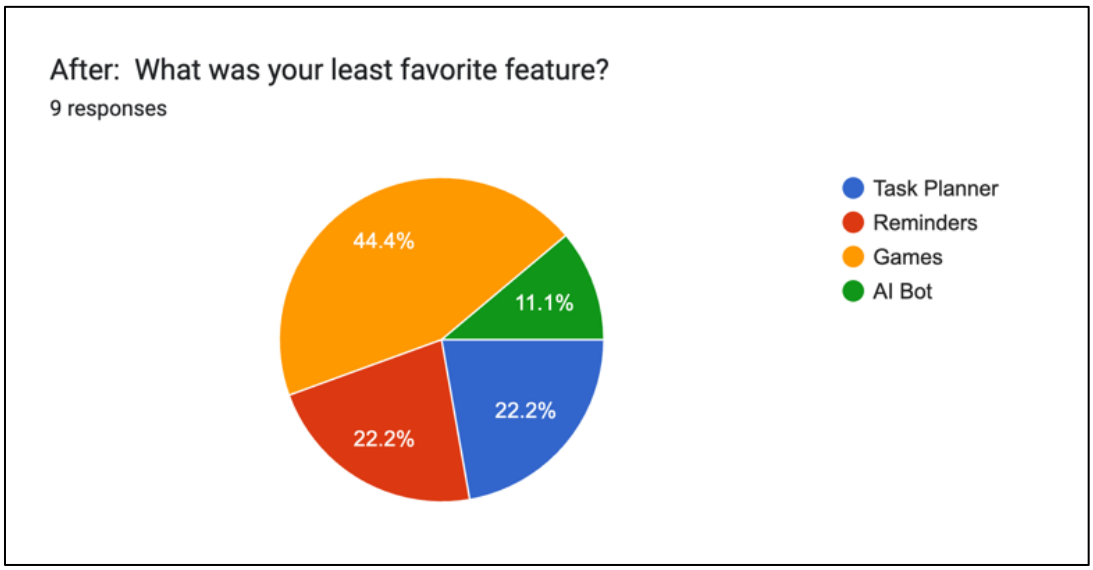


Figure 19: User's least favorite feature during use.

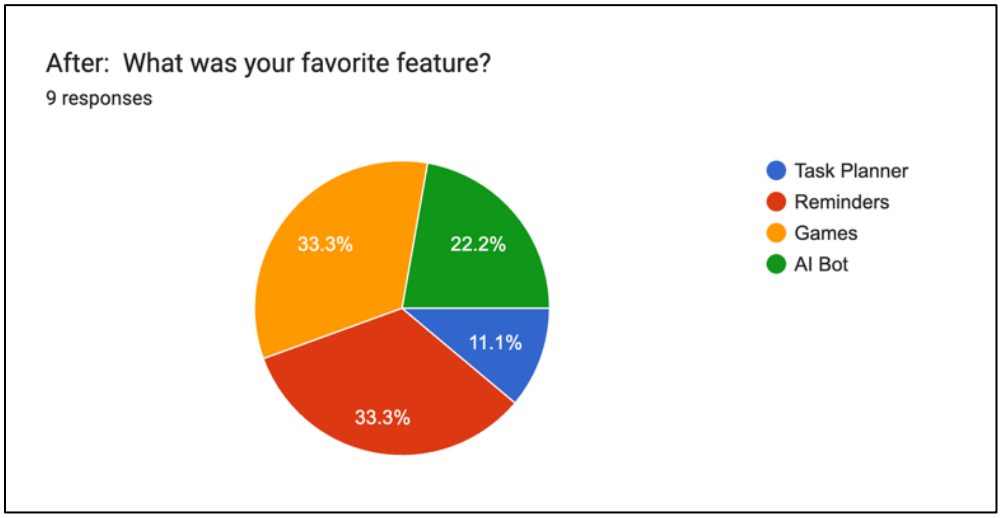


Figure 20: User's favorite feature during test.

Rating features independently generated the following averages: Task Planner 6.78, Reminders 7.22, Games 6.78, AI chatbot 7.67. Only the AI chatbot did not receive a response below neutral with the task planner and reminder both receiving at least one rating of 4. Games received a rating of 1 by one user with all others reporting 5 or above. Each feature also included at least one rating of 10. Figure 21 shows the results for the task planner rating.

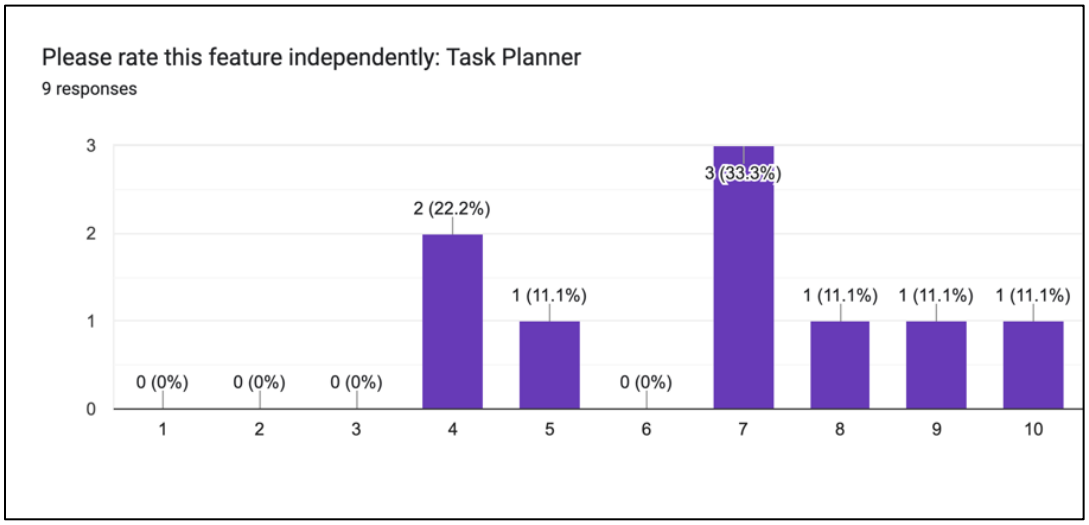


Figure 21: Ratings for Task Planner features.

Figure 22 shows the results for the reminders feature. The reminders did receive positive results but did receive 3 ratings at neutral or below. The feature seems to have proved some use but may need improvements to remain viable moving forward.

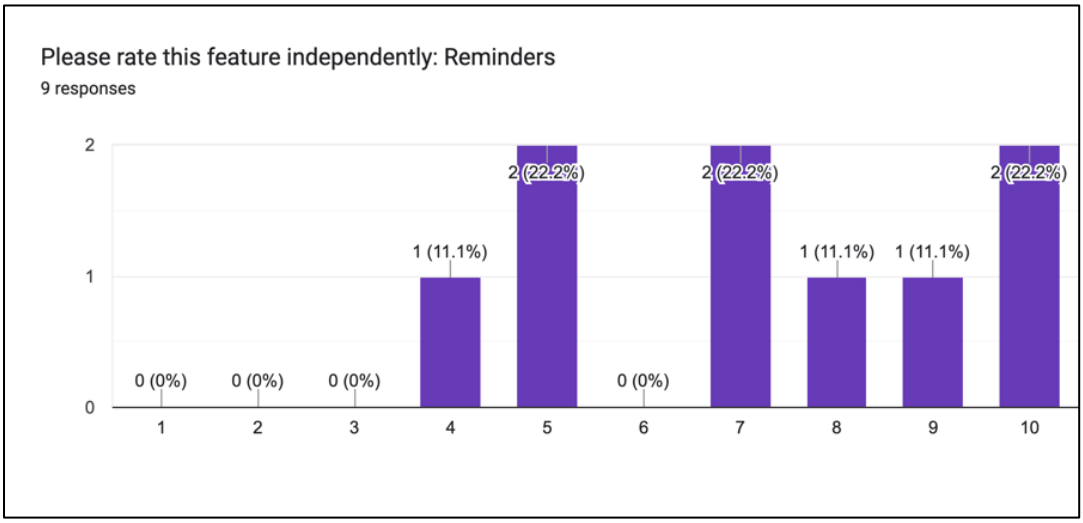


Figure 22: Ratings for Reminders features.

Figure 23 shows the ratings for the game feature. Users had the most variance for ratings of the game feature. This may have partially been due to the limitations of time and limitations of the games in the setting. This was the only feature to receive a rating of 1 from a user.

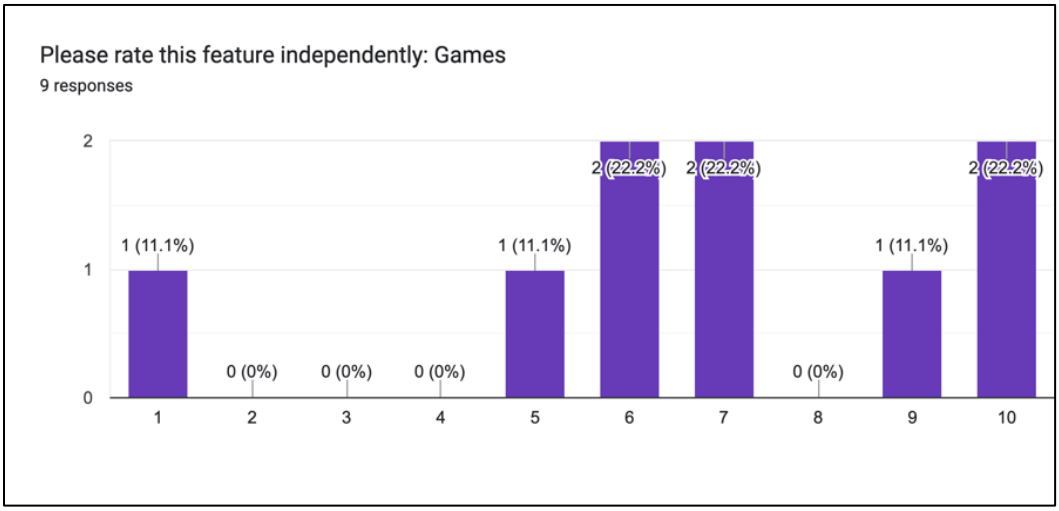


Figure 23: Ratings for Games features.

Figure 24 shows the AI chatbot responses for ratings. User overall felt positive about the experience with the chatbot. One user was in neutral while all other users gave a higher rating.

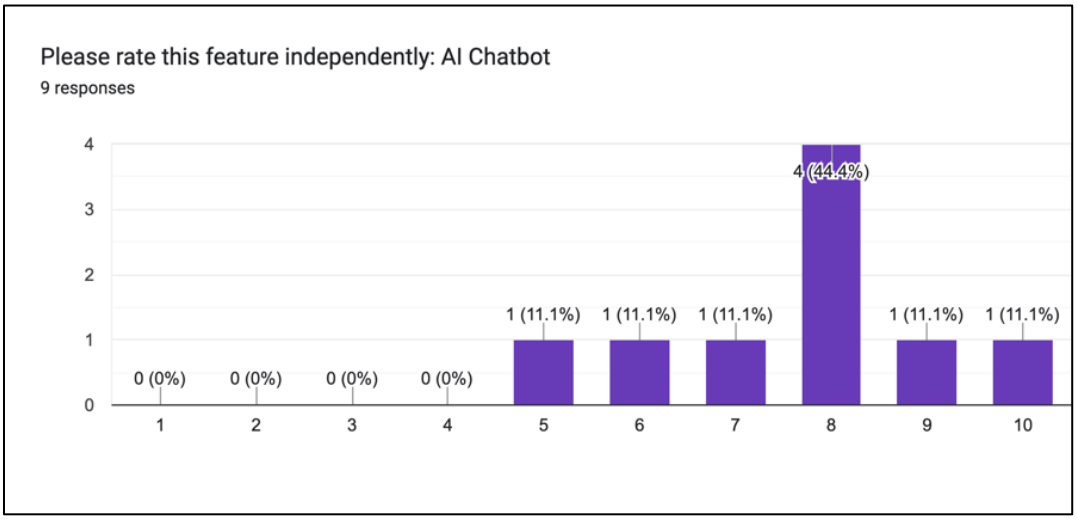


Figure 24: Ratings for AI chatbot features.

Users tended to see value in the app or the concept of the app with the average reporting for question 13 being 7.22. This indicates a likely response to the question. Figure 25 shows the bar

chart results for the question.

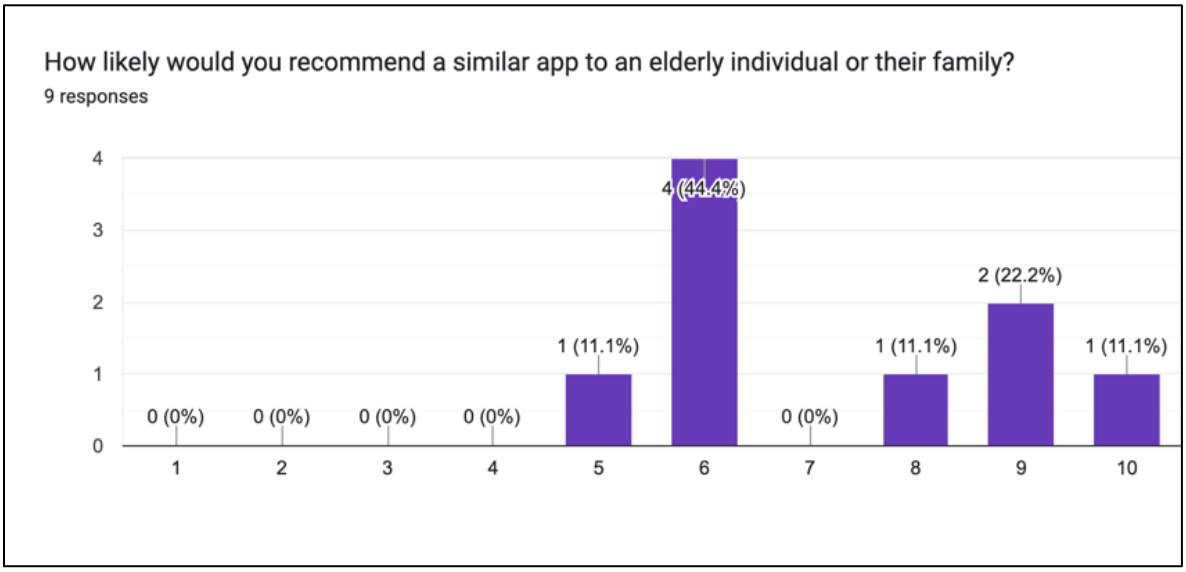


Figure 25: Likelihood of recommending the app to other elderly individuals.

The FRED avatar was also surveyed, with users reporting the attractiveness of the avatar used in the PWD app. Users reported high values for the avatar with an average rating of 8.67. All reported values were 7 or above with 33.3% of responses being a rating of 10. One user compared the new avatar and old avatar and indicated some aversion to the new avatar due to its robotic likeness.

2.4.3 **Interpretation of Results**

Quantitative data provided by Google Forms provided structured feedback on aspects such as usability, clarity of interface elements, and overall satisfaction with the NOVI app. Additionally, qualitative data from open-ended questions offered deeper insights into specific challenges faced by individuals, as well as their suggestions for improvement. By soliciting feedback on colors, font sizes, and app features, NOVI seeks to create a more intuitive and user-friendly experience. The results showed a general preference for the color scheme and layout. This would suggest continuing in the same direction for future developers. For the features, the games and task planner received the lowest ratings but still were on the positive end for users. The games may need to be revamped but also were not able to be fully enjoyed with the time limitations of the test. The task planner had some clear issues such as possible navigation issues for PWD and issues of practicality of use over other options for scheduling. The results overall ended up being positive with most users giving positive responses. Considering this, the team will designate a pass for the associated specification as the overall rating was in the good range with most users in the very good range. This did not quite meet the 80% but with low response numbers that is to be expected.

2.4.4 Recommendations

NOVI recommends that a user test group of at least 20-30 people be used. While NOVI has been unable to get in touch with many test groups, this survey is important for future development, so the team recommends that the survey be used by the next senior design group working on the project. The survey and user testing were performed by a single team member at the senior center which limited the capability to interact with potential users. In a better scenario, multiple team members should be involved with multiple phones, allowing more input to be taken at a time. The content of the survey can be improved as the app progresses to better reflect the current status.

2.5 Test 5: Daily Time Spent on App (Untested)

Daily time spent on the app will track how much the app is used, meeting the requirements for engagement. This test would require months of feedback from users who have access to a fully functioning application. For those reasons, this test will not be performed this year and is suggested for future developers to implement in their final testing plans.

2.5.1 Procedure

This test will have a user-testing group of persons with dementia and caregivers. Ideally, the majority, if not all the users should be living at home for the first iterations of the application. This is due to the stages of dementia in which the PWD is still living in their home and would most likely be more accepting and capable of using an application. The group will be given the application and allowed to optionally use it for up to 6 months. The team will keep track of the average hours the users spend on the application per day. The testing data would be acquired weekly for the duration of the 6 months. At the end of the 6-month testing period, the data will be summarized into weekly data averages for all users.

2.5.2 Data summary

It would be suggested to review this data in weekly averages and percentage change week to week. A similar point would be to use a figure like the line graph used by stock prices. This would easily show sharp rises or falls in average app use for all individuals. A scatterplot can be used with percentages as the values to see clear values for the rises or falls in use.

2.5.3 Interpretation of Results

Lower results for daily use over time may mean a lack of engagement with app features or difficulty in use. High and consistent use will indicate good engagement depending on the time spent. The trends will ideally increase overall during the trial period and become steady at some point. This steadiness would most likely be best seen as deviations less than 10% for a month or longer and not having repeated drops in usage for consecutive weeks.

2.5.4 **Recommendations**

This testing method does not include data on what is happening during the testing trial. This means that there is no data on why the user may be using the app more or not. Despite that, the engagement does model real-world use of the app. This test can be improved through the acquisition of that data which may show areas in user's lives where the app is not functioning in the proper role. This can be in the form of a survey or review of the experience at intervals during the testing process.

2.6 **Test 6: Stress Testing (Untested)**

To test the robustness and integration of a unique and specialized personality for the AI in the app the chatbot will be prompted in many uncommon ways to test the stability of the AI model in maintaining the FRED persona. That being a friendly conversation agent who can keep and maintain a conversation with the user for an extended period and is also capable of providing helpful information/advice. This test is outlined for future developers to use in a more complete chatbot feature.

2.6.1 **Procedure**

Various testing groups will be defined to test different performance metrics of the AI such as:

- Ability to navigate the user throughout the app
- Ability to set reminders
- Ability to engage in conversation.

To test the AI's ability to navigate throughout the application, the AI will be prompted to navigate to each of the 5 pages in the application 10 times. The number of failed navigation attempts and qualitative observations will be recorded. To test the AI's ability to set reminders, the AI will be prompted to set a list of 10 different reminders 5 times each. The number of failed setting reminder attempts, and qualitative observations will be recorded. The AI's ability to engage in conversation will be tested by providing the chatbot with a series of 10 random prompts in a row in five separate trials. The number of times the AI model does not try to stimulate further discussion on the previous topic and qualitative observations will be recorded.

2.6.2 **Data summary**

This data should be utilized to find weak points in the behavior of the AI and could be used to report on the robustness of the AI model as a whole. The model can be graded on its overall robustness by recording the 50 breaking points in each section with a total grade being taken out of 150 maximum points. The qualitative data for breaking points should be recorded and presented in a table and used to provide suggestions for future research.

2.6.3 Interpretation of Results

If the chatbot scores low on the quantitative score (less than 100 out of 150 points), then the quality of the chatbot should not be seen as ready for production and most aspects of the chatbot will need further development before the test is performed again. The qualitative data can also provide context as to what aspects of the chatbot need to be developed further.

2.6.4 Recommendations

Based on the overall quantitative score of the chatbot the chatbot should be improved by making adjustments to the ai model, its fine-tuning, and the model's assigned role. It is also recommended that further stress testing be conducted periodically, with adjustments made after each testing cycle to steadily improve the chatbot's performance. This iterative process will help ensure that the chatbot remains relevant and effective in engaging users and providing useful assistance. Furthermore, involving users in the testing process by soliciting feedback directly from them could provide invaluable insights into how the chatbot meets their needs and expectations, thus allowing for more user-centric improvements.

2.7 Test 7: App Connectivity

To ensure the app's reliability and user experience, connectivity tests are designed to evaluate the application's performance when accessing various features under normal and peak conditions. This aims to confirm that the app remains responsive and does not crash upon launch or during operations.

2.7.1 Procedure

Each feature within the app will be accessed in a randomly generated sequence five times consecutively without restarting the app. Features include but are not limited to, user login, data retrieval, content updates, and user settings modification. The connectivity test will also simulate real user behaviors, such as switching between features rapidly and accessing multiple features simultaneously to validate concurrent processing capabilities.

2.7.2 Data summary

The test will track the number of crashes, if any, the response time for each feature, and any anomalies observed during the connectivity tests. This data will be systematically recorded to assess the application's stability and responsiveness. Performance metrics such as load time, error rates, and downtime incidents will be documented in detail. The final prototype displayed no errors thus far.

2.7.3 Interpretation of Results

Analyzing the collected data will help identify any connectivity issues, such as features that cause crashes or significant delays. A performance threshold will be established, and any deviations from this benchmark will be thoroughly investigated. The results will indicate whether the app maintains its functionality and user experience under various conditions without compromising performance.

2.7.4 Recommendations

Based on the outcomes, specific improvements should be targeted at areas where performance does not meet the established benchmarks. This may include optimizing backend processes, increasing server capacity, or refining code for efficiency. Regular updates and patch implementations are recommended to enhance stability and ensure ongoing compliance with the latest technology standards. o It is also advisable to extend testing scenarios to cover more extreme conditions and include a larger group of beta testers to simulate real-world usage more accurately.

2.8 Test 8: Startup Loading Time

The app's loading time and connectivity to the login page through Firebase were tested to only show the loading screen for less than 3 seconds.

2.8.1 Procedure

For this test, the app was restarted 5 times, and each trial was timed for the time it took for the app to load its internal memory and connect to the Firebase.

2.8.2 Data Summary

The data for this test is listed in Table 3. The trial number is listed to the left and the corresponding time result is listed to the right. Each trial produced a time of less than 3 seconds. The highest times were for trials 4 and 5 where the time was over .900 seconds.

Table 3: Startup Time of the App

Trial	Time (Seconds)
1	0.766
2	0.850
3	0.785
4	0.938
5	0.944

2.8.3 Interpretation of Results

Every result was less than one second on a standard home internet connection. These results greatly exceeded the goal of less than three seconds. Based on these results, normal use cases will likely lead to a satisfactory loading time for the application.

2.8.4 Recommendations

It would be a good idea to test different types of internets across a wide array of devices to ensure similar loading times. It is also possible the app will take longer to load as the app's memory is increased, so more tests may be performed later in the app's lifecycle.

2.9 Test 9: Internal Memory Load Time

The app's loading times for internal memory were tested for each feature of the app to obtain results that were less than one second.

2.9.1 Procedure

Each page was accessed in a random order from the home screen and the loading time of each page was recorded using a stopwatch.

2.9.2 Data summary

Table 4 shows the resulting data for the loading time of each feature. This data is set in seconds to the thousandth place. Each page was observed a significantly different range of loading times with all being under 1 second. The longest loading times tended to occur from accessing the task planner feature. The second longest loading times occurred from the memory card game.

Table 4: Loading time of each feature in seconds.

Trial	Chat Page	Set Reminder	Task Planner	Memory Card Game	Settings
1	0.249	0.332	0.888	0.546	0.228
2	0.235	0.327	0.729	0.403	0.107
3	0.273	0.218	0.780	0.564	0.224
4	0.309	0.382	0.737	0.412	0.259
5	0.275	0.344	0.636	0.596	0.290

Each page was observed a significantly different range of loading times with all being under 1 second. The longest loading times tended to occur from accessing the task planner feature. The second longest loading times occurred from the memory card game.

2.9.3 Interpretation of Results

The data points to a few potential conclusions being made. The task planner which loads in three different page views and the json file data for the list of reminders seem to take the longest. This is likely due to the need for creating many widgets and accessing and then interpreting the file data. The memory card game likely also took more time to load as it needed to load animation data for the flipping of the cards. The results are within the parameters to be considered successful in meeting customer requirements.

2.9.4 Recommendations

An idea for future testing would be to create an artificially enlarged json data file to simulate the data of a user who has been using the app for many years and has accumulated a large amount of stored data. This can help see how drastically an increased file size would impact load times.

2.10 Test 10: ChatGPT and Open AI Connectivity

The app's speed for processing and receiving the proper data through the API calls sent to OpenAI for the speech-to-text feature in the chatbot was measured to obtain results in less than one second.

2.10.1 Procedure

The test was performed by accessing the speech-to-text function on the app from the home page and was timed using a stopwatch.

2.10.2 Data summary

The speech-to-text function was called several times within the app and each time was tested and proved to be less than the one-second threshold. The highest times from the test were from trial 1 and trial 5 which both had values of greater than .800 seconds. Table 5 shows these results with trial number and time in seconds.

Table 5: Speech-To-Text AI Response Time

Trial	Time (Seconds)
1	0.875
2	0.720
3	0.676
4	0.792
5	0.835

2.10.3 Interpretation of Results

The function appears to be implemented efficiently as the load time was consistently under the desired threshold even with long prompts. This can be considered to meet requirements when taken in context with other results for specification S05 testing.

2.10.4 Recommendations

Explorations into real-time speech-to-text processing could further reduce the lag on a function like this, especially as faster and more efficient models become publicly available.

2.11 Test 11: QARK Test (Untested)

The final application will not be complete to a level that is testable for security. In the current state, this is not a valuable test but will be for future developers. The team is submitting the full testing outline for those more familiar with the software and security testing.

2.11.1 Procedure

The QARK test is designed and used for Android penetration testing. This means that it is meant to be used on Android applications to ensure they meet security standards. Developers can implement the QARK test with their developed code. QARK is designed for use with Java or packaged APKs. The team has poor knowledge of security tests and was not able to ensure its compatibility.

2.11.2 Data summary

The data acquired from this test will be a value for the number of potential vulnerabilities, warnings, and bugs or errors. Potential vulnerabilities are defined issues that may leak protected information or allow access to restricted material. Warnings are problem areas that can be circumvented. These are areas where experienced persons may be able to exploit the app to gain information that is not readily available. Bugs and errors are lines of code that do not perform as intended.

2.11.3 Interpretation of Results

The data received indicates security and functional flaws in the code. This test is best integrated with a more complete and ready-to-distribute application.

2.11.4 Recommendations

App security will be essential in longer-term aspects of the project. This test’s importance will increase when the app is closer to distribution. The team would suggest having more experienced

persons in software security remodel the testing plan to fit better security standards. This app also will need to remodel the security structure to be testable and efficient.

2.12 Test 12: Comparable Price of App (Untested)

This will test for the specifications related to the price of the app. It will ensure that the app stays within budget for caregivers. The test for this will be redone prior to the FDR submission based on the recent changes in marketing and commercialization.

2.12.1 Procedure

The procedure to run this test requires additional research into similar applications. The team would suggest researching applications directly and indirectly used by caregivers and PWDs. Examples would include apps such as MindMate, Lumosity, and Medisafe. All these apps have different functions but have features that are designed so that they can be used by older individuals and PWDs. What is to be determined is the cost of the application and what similar functions it performs to the FRED app. The goal of this test is to determine the lowest-cost grouping of applications that can perform the same tasks as the FRED app. The example for this test is done through Google Sheets after research has been performed. To do this, one possible method is to group the apps found into pools with a correlating cost. The pools are general descriptions of the functions for the application, i.e. task planner. An Excel function selecting the lowest value in each pool would result in the lowest cost to perform all tasks of the FRED app.

2.12.2 Data summary

Data for this test can be displayed through the Excel results. Research should be done on costs of development to include the value required to cover costs. Important data to include is the cost of owning all applications needed to have the same features as the FRED application and the current price to cover development and maintenance costs.

2.12.3 Interpretation of Results

The app may be competitive in terms of features, but the competitive cost of downloading and maintaining a subscription would help ensure it is an attractive alternative to other options. App costs will increase with the number of users. It is important to have a price that covers these costs and costs related to development. A higher cost may be inevitable but can start a conversation or investigation into what can be done to lower the price to a competitive value. The app should be affordable and accessible as per customer requirements. The cost has a high impact on meeting those goals.

2.12.4 Recommendations

The team would require more research on development costs for this test to be effective. Currently, the cost of development is minimal as the app has no designated servers or paid developers. In this case, the app would be free. Information on the requirements to fund the application would allow this test to have a real, comparable value for the FRED app.

Another part of increasing the validity of the comparison is determining the method of charging users such as the freemium model that the NOVI team has suggested in this report. Differences in charging methods, such as monthly subscriptions or single purchases, can change the values required for comparison.

2.13 Test 13: Cognitive Game Score (Untested)

To assess the functionality of the games in the app, the cognitive game score test will measure how well users are interpreting the rules of the game while also assessing how challenging the games are. Since this test will require a fully functional application along with a user testing group for an extended testing period, it will not be completed during the ISD course. The following are suggestions for procedures of the test and expected results.

2.13.1 Procedure

This test will have a user testing group play the memory card game and Sudoku game. Two independent groups will be used which will include 3 subgroups: younger individuals (age 30 or under), senior individuals (age 55+), and PWDs. The subgroups will contain about 15 to 20 individuals. The two independent groups will be given either the memory card game or the Sudoku game. Users will play the game twice a day for 5 days. Scores will be calculated based on the individual scoring metrics for the games.

2.13.2 Data summary

Data for this will be displayed as a histogram of game scores. This will provide data on the average difficulty of the game. Scores for the younger groups and senior groups would ideally be left-skewed with a heavier number of scores in the higher ranges. Game scores have yet to be determined and will need to be considered before performing this test.

2.13.3 Interpretation of Results

Results will show how difficult the game is and determine if that will need to be increased or decreased. If many participants are struggling, this may indicate the game is too difficult. If many younger individuals are scoring well but the older individuals and PWDs are not scoring well, this may mean the game has some missing aspect of accessibility. Overall, the game scores should increase after the first day of testing and should not drop considerably. A small increase in scores

with moderately high test scores would mean the specification is meeting requirements for accessibility and engagement. Low scores may show too much difficulty in the game which would fail the requirements.

2.13.4 Recommendations

This test can be improved by timing the games to determine if the games are too short or too long. This would show better results for engagement. The games will also require scoring metrics that are understandable in the context of this test. Completion is a possible metric but is not efficient in determining difficulty.

2.14 Test 14: Mood Improvement (Untested)

This test is used to determine if the app is being productive in improving mood and relieving any burden on the user or caregiver. This test is a plan for future developers and teams to improve the acceptance of the final product. The impact that app would have on an individual at this stage in development would be minimal and the information from this test would not be beneficial until development is at a state closer to market availability.

2.14.1 Procedure

A user testing group of elderly individuals (5-10 individuals) and PWD (5-10 individuals) should be organized and surveyed daily on their mood for 1 month. This will serve as a baseline for the test. The user testing group of elderly individuals and PWD will be given a complete FRED app and will be tasked to use it for an extended period (3-6 months). Users will be asked to report their mood with a five-point scale from happy to sad. For previous models of the FRED robot sad, happy, and neutral faces were used in place of this to survey mood. This may be a good alternative to real numbers as users may connect better with faces. Figure 26 shows a similar chart that could be used. At the end of testing the users will continue to be surveyed for 1 month on their mood. This will be data used to determine if mood decreases or increases after stopping use, essentially serving as another baseline.

Figure 26: Face scale for mood reporting.

2.14.2 **Data summary**

The data acquired will include two controls pre-app use and post-app use. If the faces are used in the trial, they are given values from 1 to 5 with 1 being the left-side red face and 5 being the right-side green face. The control data will independently be compared to the average mood with app use over the trial period. Everyone who reports consistent use of 5 days or more per week will be included in the final summary of data. Those who do not report consistent use would not have quality results for this test as the app would be less likely to have affected their mood. The data can be displayed for each user as an average value by week. Weekly values can be compared by percentage change.

2.14.3 **Interpretation of Results**

Improved moods over the trial period may indicate the app is functioning to help individuals in day-to-day life. Data from the PWD side is essential for determining the success or failure of the app to meet these requirements. A passing result from this test would be the increase in mood averages with extended app use, ideally with growth from the control of 10% or more. A failure for this test would be a decrease in mood of more than 10% from the control.

2.14.4 **Recommendations**

This test does not take many factors into account that may be affecting mood outside of the application. The data from this test should be considered but should not fully judge the ability of the application. Using surveys throughout the test may show reasons for sharp changes in mood.

The data may also reflect the progression of the disease. The user and the PWD should consult their primary care physician for drastic changes in mood not relating to a specific event. PWD are known to have mood swings as a symptom.

A larger testing group would better show results from this test. Numbers are important for the statistical significance of the test. Additionally, including a second testing group that will use other applications for PWDS may improve comparative results.

If this test is successful, the mood tracker may be a feature to implement in future designs.

2.15 **Test 15: Typeface**

This test will determine if the size of the text in the app meets the requirements for accessibility. This will be done with a team member who will be impaired by distance from the device. The chatbot is used as this feature will have the smallest and most extensive text. For the device, an Android smartphone was used as this is the prototype device.

2.15.1 **Procedure**

This test used the prototype application's FRED Chatbot. FRED was given a simple prompt that would produce 2 to 4 lines of response text. The participant (or team member) read the responses at set distances of 20, 40, 60, and 80 inches. The responses were then repeated by the participant and compared to the original text. The accuracy of words seen by the participant to words typed by FRED was graded as a percentage value. This grade came from editpad.org which has content similarity software. The original text is input as the first content and the repeated words are input as the second content. In this trial, a value of 90% is considered a passing test. Figure 27 shows an example of the Editpad software.

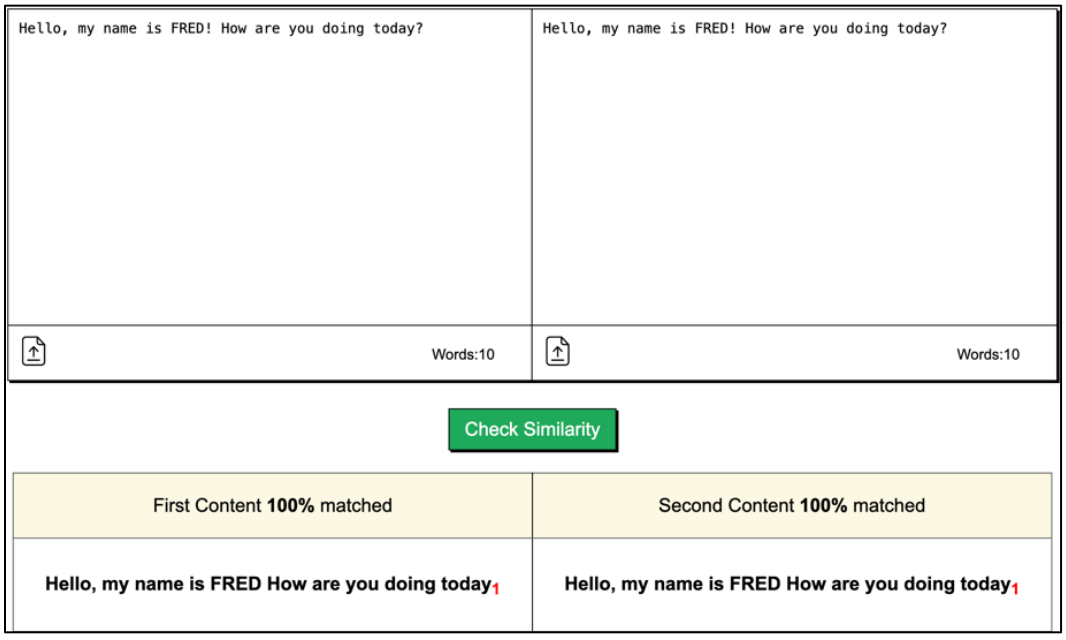


Figure 27: Editpad text similarity checker.

2.15.2 **Data summary**

The data from this test is displayed in Table 6. This table's left column has the distance the text was read from, and the right column has the percentage match from the Editpad software.

Table 6: Percentage matching for text at distances of 20, 40, 60, and 80 inches.

User distance from screen	**Percentage Match**
20 inches	100%
40 inches	80%
60 inches	15%
80 inches	10%

2.15.3 **Interpretation of Results**

The test found that the text size is reasonably legible from normal distances for using a phone if the individual has standard vision or standard corrected vision. At greater than 40 inches, the readability of the text decreases rapidly. The text had been improved in some respects before this trial but will require larger sizes to meet requirements for readability. At the current state, the app passes these standards for acceptance.

2.15.4 **Recommendations**

Improvements to this test would be to include elderly individuals for reading the text as this will provide results with the most quality in context to actual accessibility. Distance is an important factor for determining the quality of eyesight, but the test results would best fit true user standards by having the phone in a more natural position with users who are most like the population the app is being designed for.

Test 16: Color Contrast

To test the color contrast and ensure the app is meeting accessibility standards, the selected colors of the app were tested through the WebAIM Color Contrast Checker. This is a free online software sponsored by WebAIM that helps developers and designers know how well their products match accessibility and usability standards.

Table 7 shows the list of colors used in the app with their name and hex codes as indicated in the coolors.co website. The checker has 2 tests depending on which of three modalities the color is used in. The NOVI team checked each color that would be adjacent to the application to ensure that the colors were noticeable from each other.

Table 7: List of colors with color name and hex.

Color Name	**HEX**	**Color**
Cool Black	052F5F	
Alice Blue	EBF2FA	
Dark Turquoise	1ED0D8	
Black Chocolate	191716	
Light Sea Green	17A3AB	
Auburn	A82428	
Feldgrau	465159	
Maximum Green	5E932A	
Midnight Green (Eagle Green)	0E595D	
Baby Powder	FBFEF9	
Light Silver	D9D9D9	

2.15.5 **Procedure**

The colors were correlated to their hex code and mapped out as foreground or background colors based on their use in the app. A foreground color would be a text or graphical object while the background is the surrounding color or screen color that the text or graphical object is overlayed on. The team put in one color for the foreground and then repeated the contrast checker with each background used for that foreground color. The checker judges based on 3 text/object types for 2 Web Content Accessibility Guidelines (WCAG):

- Normal Text
  - WCAG AA
  - WCAG AAA
- Large Text
  - WCAG AA
  - WCAG AAA
- Graphical Objects
  - WCAG AA

Each check on the software has a pass or fail for these guidelines. Colors must pass for text and objects that they may be used in. Figure 28 shows an example of the WebAim software test for a color combination. This includes a contrast ratio which the test uses to determine which standards

are passed or failed along with the results below for each text or object type and the applicable WCAG standard.

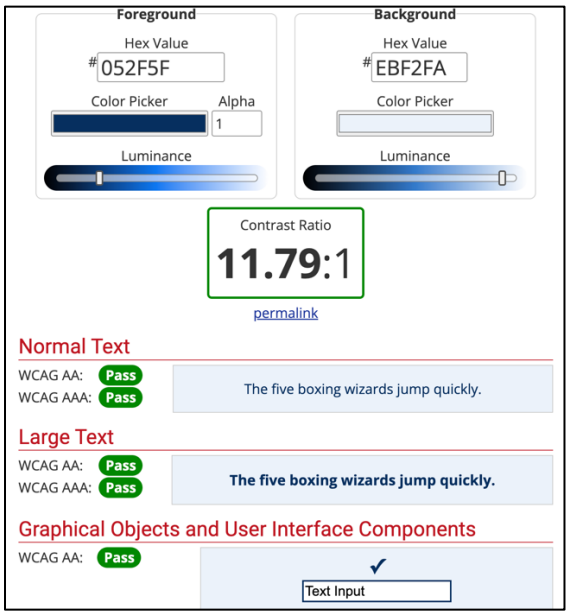


Figure 28: Example of WCAG testing through WebAIM software for color values.

2.15.6 **Data summary**

Figure 29 shows a table of the testing results from Excel for each test case. The figure shows comparative colors for all colors in the application. The top row contains the foreground colors used in testing while the left side contains the background colors. At the intersection of foreground and background colors, the cells contain a combination of P and F for pass and fail. The order correlates with the standards listed above. For example, a result of FFPFP would mean that normal text failed both WCAG AAA and AA, large text passed WCAG AA and failed WCAG AAA and graphical objects passed WCAG AA. An all-pass result indicated by green highlighting means no errors against the pair of colors concerning contrast. A yellow highlighted square means there is at least one pass or at least one fail for a standard. A red highlighted box means that all standards fail for any text or object. Cells containing n/a are either colors that are the same or colors that were not intended to be used together. Listed at the bottom of the figure are the hex codes for that column's color.

	Fore										
Back											
	n/a	PPPPP	ppppp	FFFFF	FFPFP	FFFFF	FFFFF	FFPFP	n/a	PPPPP	PPPPP
	PPPPP	n/a	FFFFF	PPPPP	FFFFF	PFPPP	PPPPP	FFPFP	PPPPP	n/a	n/a
	PPPPP	FFFFF	n/a	PPPPP	n/a	FFPFP	FFPFP	n/a	n/a	FFFFF	FFFFF
	FFFFF	PPPPP	PPPPP	n/a	PFPPP	FFFFF	n/a	FFFFF	FFFFF	PPPPP	PPPPP
	FFPFP	FFFFF	n/a	pfppp	n/a	FFFFF	FFFFF	FFFFF	n/a	FFPFP	FFFFF
	FFFFF	PFPPP	FFPFP	FFFFF	FFFFF	n/a	FFFFF	FFFFF	FFFFF	PPPPP	PFPPP
	FFFFF	PPPPP	FFPFP	n/a	FFFFF	FFFFF	n/a	FFFFF	n/a	PPPPP	PFPPP
	FFPFP	FFPFP	n/a	FFFFF	FFFFF	FFFFF	FFFFF	n/a	n/a	FFPFP	FFFFF
	n/a	PPPPP	FFPFP	FFFFF	n/a	FFFFF	n/a	FFFFF	n/a	PPPPP	PFPPP
	PPPPP	n/a	FFFFF	PPPPP	FFPFP	PPPPP	PPPPP	FFPFP	PPPPP	n/a	FFFFF
	PPPPP	n/a	FFFFF	PPPPP	FFFFF	PFPPP	PFPPP	FFFFF	PFPPP	FFFFF	n/a
	052F5F	EBF2FA	1ED0D8	191716	17A3AB	A82428	465159	5E932A	0E595D	FBFEF9	D9D9D9

legend:	green	yellow	red
	passes all standards	fails some standards	fails all standards

Figure 29: Excel datasheet for color contrast WCAG test results.

2.15.7 **Interpretation of Results**

The colors used currently complete most WCAG standards to an acceptable degree. Despite failing in some tests, the failures do not apply to the text or objects that use the colors in the app. This follows the results from user testing which have not found much negative data on the colors used or visual issues with the colors used. Some colors, such as 1ED0D8 and 17A3AB, are different shades of the original color and were specifically designed to work with certain other colors in the app. More work needs to be done to ensure the colors fit these results in each feature and to standardize colors with functions in the app. These results allow the team to consider the requirements and specifications for accessibility through color contrast to be met.

2.15.8 **Recommendations**

This test is efficient for determining general accessibility for normal or semi-normal color vision.

It does not check the likeability of the color and it does not consider increased difficulty in differentiation for colorblind individuals. The team used colors that are generally differentiable by colorblind individuals but did not additionally test the colors for the attractiveness of those colors to colorblind individuals. Suggestions would be to include additional testing software and a survey to determine if the colors are attractive to the general population the app is looking to serve as well as accessible to colorblind individuals.

This check does not include multiple fonts, or the graphical objects being used with the color. Variables such as these may also impact the practical results of this test and yield different reactions from individuals. More research should be done into fonts and font styles that may improve aspects of readability and differentiation of aspects within the app. Graphical objects are a major point of interest as well. In addition to color for these objects, the objects themselves are important for usability in the application. Part of the intuitiveness of an app is using common objects to indicate actions, for example, using a house icon as the home button or using a left-

facing arrow as the back button. It will be important to determine if the objects used are effective in their purpose while also being unique to the application style. Future developers should consider that for tests such as this one.

3. Summary and Recommendations

This section will summarize results and provide further recommendations. The team will consider the results that were obtained along with their impacts. Additional tests are mainly listed in the above sections but further reasoning on what might be done for the improved integration of testing will be included in testing recommendations. Unmet results will evaluate the tests that did not meet requirements and failing specifications.

3.1 Key Results and Impact

The app had some key results from the testing performed. Acceptance testing did not provide the results that the team had originally thought would be obtained, but the overall feedback from the final prototype and final reports has been largely positive. The scope of work for the project has been changed multiple times since the start of the school year, and the progression of the project has reflected this. The results from testing are minimal but show clear paths toward improving the application to a level that can be readily available to users. Since this app has been designed from scratch, the failures of testing are more useful than the feedback in some cases. The results of the caregiver surveys and the UT student and staff surveys help define a better direction to take the application that will meet more requirements.

The results for technical and software aspects of the app will help direct the focus of future development, showing which aspects need the most work. Aspects like loading time and connectivity show that the app is functional in most regards. This also allows future developers to begin user testing since the application would be at a sufficient level operationally to hand to a user.

The tests performed support the business case for this project in more regards than test 12 which outlines a procedure to accommodate costs. The Small Business Innovation and Research (SBIR) grant requires a research plan that the results of these procedures can qualify as. Some of the tests may also help Dr. Zhao record user testing and trials that would be required for the SBIR submission. In this case, the results can be improved with time, but it is more important to have a clear path for progressing to standards during that time.

3.2 Testing Recommendations

User testing was the most difficult aspect of testing. Finding both a population and the time to perform testing was not within the capabilities of this project since the app was developed with no prior work done. With an initial prototype now complete, future development can focus on user testing. The tests outlined in this volume can be used to model user testing. The user testing groups

are difficult to access, so it would be advised that finding the testing population is a priority. Reaching this group sooner will allow user testing to be performed longer and acquire more relevant data.

For the software test, there are constant updates to the implemented code and outside references. Things such as ChatGPT are already producing newer versions that could be used in the app. It would be suggested to ensure that software tests are still completed during user testing at some intervals.

One aspect that was not well addressed during development was the implementation of security software. The team has little experience in this area and would not have been able to include any complex security structure. Security will be an important point in a developed and available app. This is true not only to ensure the app stays functional but also so that users stay safe as personal data, possibly including medication and location could be accessed by hackers. The security tests for the app should be improved to reflect better results for that specification.

Testing is primarily oriented towards the developed app and software implemented into it. It is somewhat lacking in business aspects as app economics are volatile and complicated. A team of knowledgeable persons in app development may help improve specifications of affordability by fully analyzing the costs of development and the ability of the app to make profits.

3.3 Unmet Results

The results of tests performed yielded a mixture of passing and failing specifications. The most notable failures were in the UT staff and student survey and the PWD user survey. For the UT staff and student survey, only four responses were generated. The small sample size prevents the survey from being very impactful or reflective of the actual population of users. Still, the results from the four respondents garnered a 53% rating of the overall experience of the app, which failed the 80% specification. The other notable failure was the lack of testing for users with dementia. NOVI had planned to create and send out a survey to people with dementia; however, due to a lack of availability of nursing homes and it being a vulnerable population, NOVI was unable to gain access to potential users. Since the team had planned to send out a survey, the lack of data is considered a failure.

Appendix A. Complete List of Acceptance Tasting

Table 8 lists all tests that are performed or suggested for the FRED app's final prototype. These tests adhere to the indicated specification in the specification column. The test description is in the acceptance test column with the target and result adjacent to it. Tests are numbered for organizational purposes.

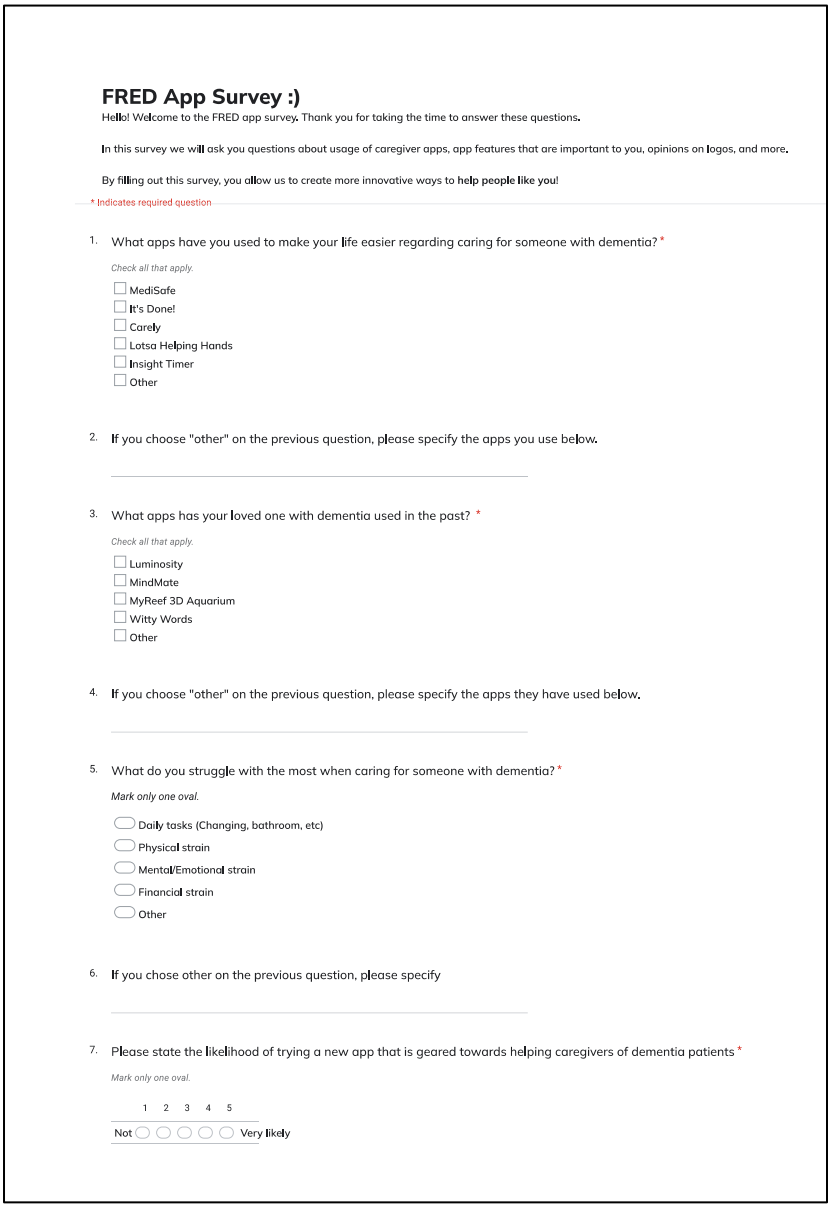
Table 8: Product Specifications and Acceptance Testing Results for Success

Test No.	Product Specification	Acceptance Test	Target	Result
Test 1	S01 Task Completion Rate	Users will be tasked to complete certain goals within features	>90% task completed	Untested
Test 2	S02 User Feedback: caregiver feedback	Surveying caregivers on UI elements.	>80% average rating	Fail
Test 3	S02 User Feedback: demo feedback	Surveying UT affiliated students and staff on prototype experience.	>80% average rating	Fail
Test 4	S02 User Feedback: PWD user feedback	Surveying PWDs on their experience with complete MVP application	>80% average rating	Pass
Test 5	S03 Daily Time Spent on App	Track usage of app by testing population	Progressively higher usage	Untested
Test 6	S04 Stress Testing	Ensure AI chatbot responds properly to user input	No hallucinations and proper conversational behavior 95% of the time when prompted	Untested
Test 7	S05 Loading time: App Connectivity	Ensuring the application does not crash on launch or when accessing features	Use all features in the app in a randomly generated order 5 times without restarting the application.	Untested

Test No.	Product Specification	Acceptance Test	Target	Result
Test 8	S05 Loading/Lag Time: Loading page time	App loading time and connectivity to login page through Firebase	< 3 seconds	Pass
Test 9	S05 Loading time: App Connectivity	App loading of internal memory timed and below particular threshold	< 1 second	Pass
Test 10	S05 Loading time: ChatGPT and Open AI Connectivity	API call to Open AI's Whisper and ChatGPT models for speech to text load time	< 1 second	Pass
Test 11	S06 Vulnerability assessment	Test app through QARK for security	High safety score	Untested
Test 12	S08 Comparable Price of App	Analyze and compare average costs of apps that perform similar functions	At or below cost of combined comparable apps	Untested
Test 13	S09 Cognitive Game Score	Keep track of user game scores to determine usability and difficulty		Untested
Test 14	S10 Mood Improvement	Survey user mood over time with app use	Progressive increase in mood	Untested
Test 15	S11 Typeface	Show positive results from survey data on typeface	>90% accuracy	Pass
Test 16	S12 Color contrast	Use WebAIM contrast checker to match accessibility standards on adjacent colors	Pass WCAG AA and WCAG AAA standards for all text and graphical object types	Pass

Appendix B. Acceptance Testing Results

Figure 30 and 31 show the caregiver survey used. This is a copy of what caregivers saw during their survey.



FRED App Survey :)

Hello! Welcome to the FRED app survey. Thank you for taking the time to answer these questions.

In this survey we will ask you questions about usage of caregiver apps, app features that are important to you, opinions on logos, and more.

By filling out this survey, you allow us to create more innovative ways to help people like you!

* Indicates required question

1. What apps have you used to make your life easier regarding caring for someone with dementia? *

Check all that apply.

- [ ] MediSafe
- [ ] It's Done!
- [ ] Carely
- [ ] Lotsa Helping Hands
- [ ] Insight Timer
- [ ] Other

2. If you choose "other" on the previous question, please specify the apps you use below.

3. What apps has your loved one with dementia used in the past? *

Check all that apply.

- [ ] Luminosity
- [ ] MindMate
- [ ] MyReef 3D Aquarium
- [ ] Witty Words
- [ ] Other

4. If you choose "other" on the previous question, please specify the apps they have used below.

5. What do you struggle with the most when caring for someone with dementia? *

Mark only one oval.

- ◯ Daily tasks (Changing, bathroom, etc)
- ◯ Physical strain
- ◯ Mental/Emotional strain
- ◯ Financial strain
- ◯ Other

6. If you chose other on the previous question, please specify

7. Please state the likelihood of trying a new app that is geared towards helping caregivers of dementia patients *

Mark only one oval.

	1	2	3	4	5	
Not	◯	◯	◯	◯	◯	Very likely

Figure 30: FRED App Caregiver Part 1

8. If you were to use this new app for caregivers, what features would you want it to have? *

*Note: Loved one is the person you are caring for

Check all that apply.

- [ ] Information on dementia and caregiving
- [ ] Self-care features (guided meditation, journaling, etc)
- [ ] Ability to see loved one's location and activity levels
- [ ] Ability to add notes on loved one for others on care team to see
- [ ] Reminder feature
- [ ] Schedule/Task planner feature
- [ ] Local community page with local dementia resources and events
- [ ] Chatroom with other caregivers
- [ ] AI Chatbot to answer questions

9. Please rank how visually appealing you find this color pallet. *

Mark only one oval.

	1	2	3	4	5	
Ugl	◯	◯	◯	◯	◯	Very appealing

10. Would you encourage your loved ones in the early stage of dementia to use an app designed to help their cognitive function, social engagement, and organization? *

Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ Maybe

11. If your profile on the app was linked to your loved one's, what would you like to see? *

Check all that apply.

- [ ] Tasks they have completed on their own
- [ ] Location of your loved one

The following two pictures are potential logos for our FRED app

A)

B)

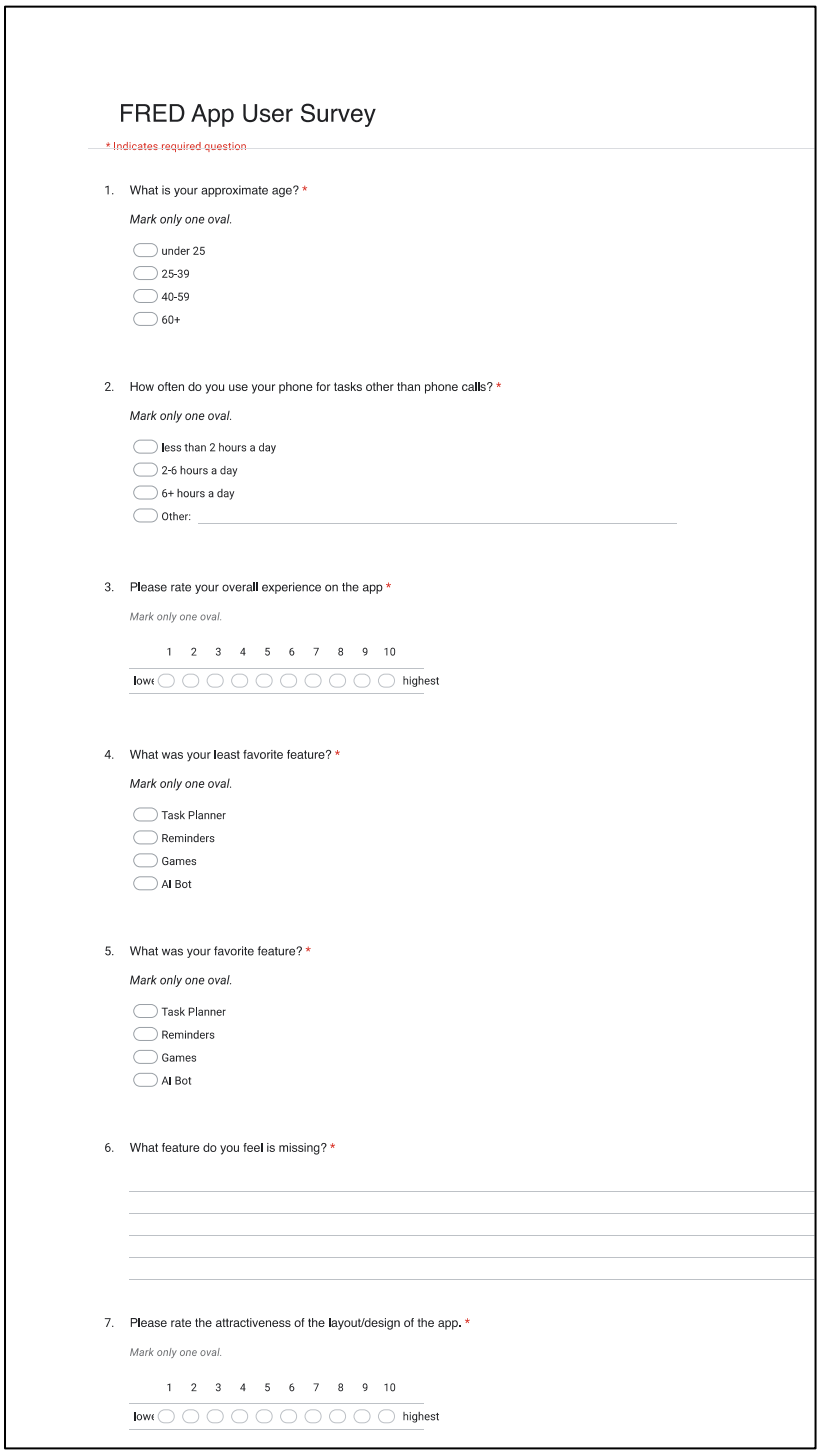
12. Please state which logo you like the most *

Mark only one oval.

- ◯ Option A
- ◯ Option B

Figure 31: Fred app caregiver survey part 2

Figure 32 and 33 show the survey used in test 3 for the UT staff and students. This is what was distributed via Google Forms.



FRED App User Survey

* Indicates required question

1. What is your approximate age? *

Mark only one oval.

- under 25
- 25-39
- 40-59
- 60+

2. How often do you use your phone for tasks other than phone calls? *

Mark only one oval.

- less than 2 hours a day
- 2-6 hours a day
- 6+ hours a day
- Other: _____

3. Please rate your overall experience on the app *

Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
lowe	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	highest

4. What was your least favorite feature? *

Mark only one oval.

- Task Planner
- Reminders
- Games
- AI Bot

5. What was your favorite feature? *

Mark only one oval.

- Task Planner
- Reminders
- Games
- AI Bot

6. What feature do you feel is missing? *

_____

_____

_____

_____

_____

7. Please rate the attractiveness of the layout/design of the app. *

Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
lowe	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	highest

Figure 32: UT staff and student user survey part 1

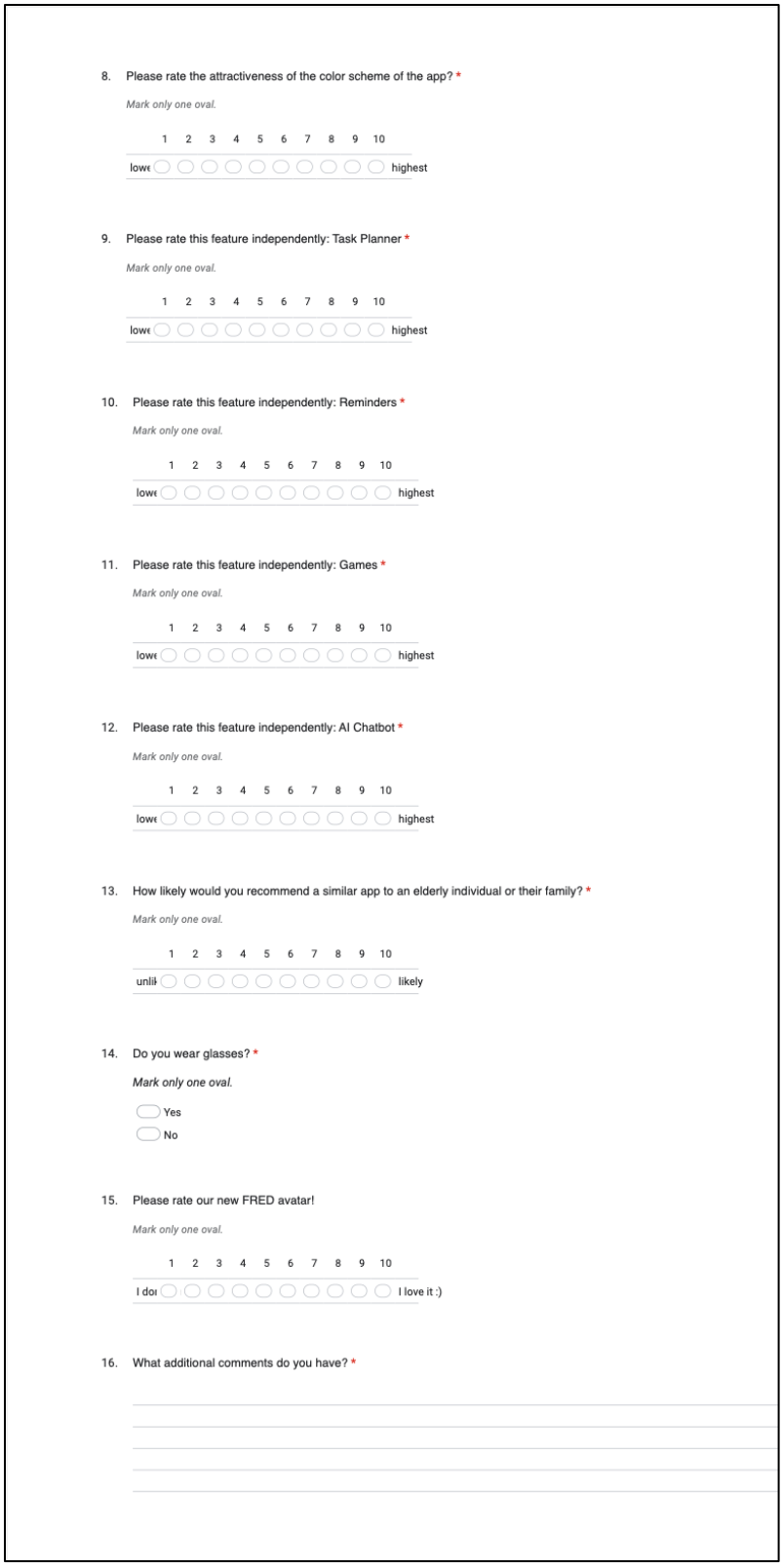


Figure 33: UT staff and student user survey part 2

Final Design Report Volume 4: Product Manual

April 15, 2024

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List of Terms and Abbreviations

AI	Artificial Intelligence. A field of computer science focused on creating systems and machines that can perform tasks typically requiring human intelligence, such as learning, problem-solving, and decision-making.
API	Application Programming Interface. A software intermediary that allows two applications to talk to each other and share data within and across organizations.
ADRD	Alzheimer's Disease and Related Dementias. The broad range of neurodegenerative diseases fall under this category.
ISD	Interdisciplinary Senior Design. An educational program at the University of Tennessee where students work with companies to develop industrial and commercial prototypes.
MVP	Minimal Viable Product. A version of a product with just enough features to be usable by early customers who can then provide feedback for future product development.
OS	Operating System. Computer operating systems such as Microsoft, Linux, or iOS.
SBIR	Small Business Innovation Research. Programs to fund a diverse portfolio of startups and small businesses across technology areas and markets to stimulate technological innovation, meet Federal research and development needs, and increase commercialization to transition research and development into impact.
UX/UI	User Experience / User Interface. User experience relates to how a user feels whenever they interact with a product or service. User interface refers to the touchpoints a person uses to engage with a digital product.

1. Introduction

This volume will improve on the necessary software and information required to develop the FRED application. This will include information regarding the application programming interfaces (API) used and the information transferred between the API and the application. Additionally, the volume will explain the process to set up and run the developer version of the application. Setting up the environment to continue development will include determining a text editor, installing Flutter, connecting to GitHub, downloading packages, and running the application. Additional troubleshooting information is included with errors and bugs the development team has run into while working along with the fixes that were incorporated. Tips and recommendations for improving development are listed to help future development stay organized and work efficiently.

1.1 API Information

API calls are used to transfer information between the server and the code. Three APIs are used in the code for the app: ChatGPT, Firebase, and Notification. Table 1 lists these APIs along with their use within the app and a link to them. ChatGPT is an AI software written by Open AI. Firebase is a backend cloud computing service. Twilio is an API for cloud communications. Nylas is an API for email communication.

1.1.1 ChatGPT API

OpenAI is a private research laboratory focusing on the development of artificial intelligence technologies. Their most notable creation is ChatGPT which is a large language model designed to generate human-like responses and engage in natural language conversations. According to OpenAI's terms and policies, data submitted through the paid OpenAI API is not used to train OpenAI models or improve OpenAI's service offering. OpenAI does not share user content with third parties for marketing purposes. The API is used for the chatbot features and may be further implemented with navigation in the app. The lab run by Dr. Zhao will be upgrading to ChatGPT 3.5 turbo which will improve the processing and functionality of the service.

1.1.2 Firebase API

Firebase is a comprehensive mobile and web application development platform created and hosted by Google. It offers a wide range of services such as real-time database, authentication, and cloud storage. Firebase Authentication uses a strong, adaptive hash function to hash the password and automatically adds a unique salt to each user's password before hashing. Firebase also provides the auth variable to check if the requestor's user information matches the user information associated with the requested data. Therefore, users can only read and write to their data. In the application, firebase is used for the login page and the task manager. In Firebase, the structure of the user data is the same as Figure 1 for the task manager to push a reminder to the API. The second structure, shown in Figure 2, is the structure used to pull data from Firebase to store locally.

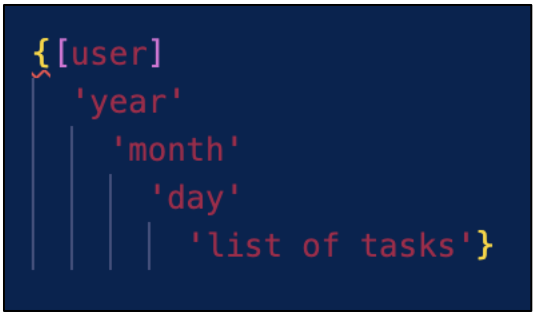

Figure 1: Data structure 1 for Firebase

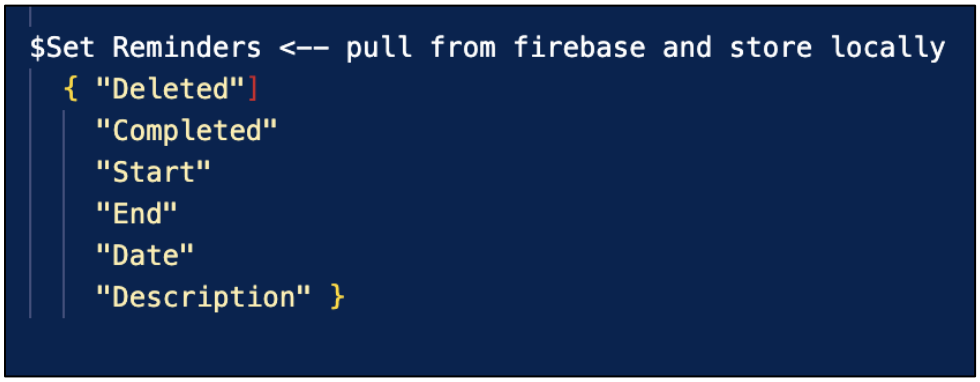

Figure 2: Data structure 2 for Firebase

1.1.3 **Twilio API**

Twilio is a cloud communications platform that allows software developers to programmatically make and receive phone calls, send and receive text messages, and perform other communication functions using its web service APIs. In the app, Twilio is used for text reminders. In the current state, the app is not funded enough and is not at a developmental state to reasonably purchase this API.

1.1.4 **Nylas API**

Nylas is a tool designed to connect applications with different email, calendar, and contact providers. It can be used with different email services and will eliminate the need to reintegrate for different services. In the app, Nylas is used for email reminders. Like Twilio, the Nylas API is not reasonable in this stage of development but is a suggested API to integrate into more complete prototypes.

Table 1: API calls and use

API used	**Use**	**Link**
ChatGPT	AI chatbot	https://openai.com/blog/introducing-chatgpt-and-whisper-apis
Firebase	Reminders and task planner	https://firebase.google.com/docs/reference
Twilio	Push notifications	https://pages.twilio.com/twilio-brand-sales-namer-1?utm_source=google&utm_medium=cpc&utm_term=twilio&utm_campaign=G_S_NAMER_Brand_Twilio_Tier1&cq_plac=&cq_net=g&cq_pos=&cq_med=&cq_plt=gp&gad_source=1&gclid=CjwKCAjwoPOwBhAeEiwAJuXRh18pHposG5aWBBXfarbrbHWEnZh9lesObvDjR_fnLOURu2cAAmuRDRoCxMQQAvD_BwE
Nylas	Email notifications	https://www.nylas.com/products/?utm_source=google&utm_medium=cpc&utm_campaign=032023-email-request-demo&utm_term=nylas&utm_content=&gad_source=1&gclid=CjwKCAjwoPOwBhAeEiwAJuXRh2w7iGEil0995BUKocyn2q6JfL4m_CsTXB4PzLCxCQ4CYRLn0MdxkRoCemsQAvD_BwE

1.2 **Setting up development**

Note to reader: The text in green indicates command line inputs. The bolded letters **indicate a dropdown selection in visual studio code.**

The NOVI team would not suggest involvement in the software development of the FRED app without practical skills in coding. The app was developed using Flutter which runs the Dart programming language. With the consideration that the coder is experienced in these, only the setup and access to files will be detailed.

The operating system (OS) used to develop the app was Microsoft. Using an alternative OS would not be recommended without experience. Apple iOS can also be used in cases where Microsoft cannot be accessed. In Microsoft and iOS, an efficient and commonly used text editor is Visual Studio Code. This text editor can run all packages required to access Flutter applications. To install this, use the Microsoft website or the App Store. Running the commands listed in this manual will also require Git for the respective OS.

During setup, two primary things need to be installed for the app to run: Flutter SDK and Android Studio. Flutter SDK can be used as an extension of Visual Studio Code. This can be installed by using the command palette type in `flutter.` Select **Flutter: New Project** from this input. This selection will bring up the option to locate or download Flutter SDK. If it is not already installed, select **Download SDK**. A dialog will display prompting **Select Folder for Flutter SDK**. Choose a valid location and select **Clone Flutter**. Flutter will download along with the required Dart packages. Once the installation is complete, the software will prompt the selection for **Add SDK**

to PATH, select this. Flutter should be operational after this procedure. If there are issues the Flutter website can be a reference for troubleshooting.

The code for the app is distributed via GitHub. The repository can be cloned by accessing ZhaoRobotLab. Figure 3 shows the repository where this can be taken from. Copy the link and enter the command `git clone https//github.com/ZhaoRobotLab/frednovi.git` in the command terminal for cloning the code to the personal computer. To run the code the command `flutter run` can be input bringing up the work done so far. Dart and other language or structural aspects of Flutter will require extensive knowledge of software development to understand how to implement improvements and redesign. It is not suggested for beginner programmers to be involved in this step of development.

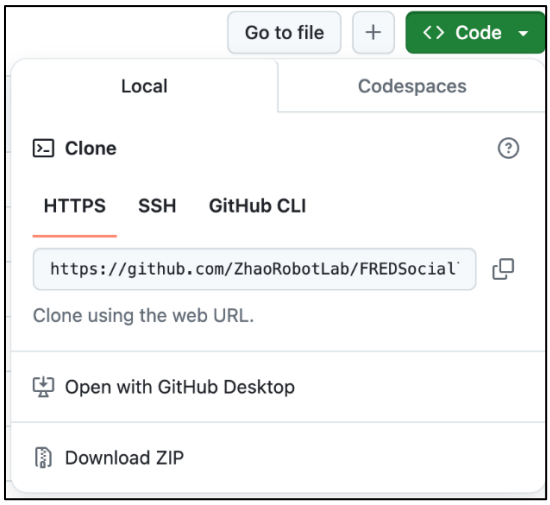

Figure 3: GitHub Repository

Android Studio will be required to run the Android version of the app. This will require VM acceleration to run. Android Studio will require the following components to be downloaded from their website.

- Android SDK Platform, API 34.0.0
- Android SDK Command-line Tools
- Android SDK Build-Tools
- Android SDK Platform-Tools
- Android Emulator

For first-time setup, you will have to configure a device through Android Studio. In the settings dialog, find **SDK Manager**. From here navigate to Tools and select **Device Manager**. Select **Virtual** and **Create Device**. A dropdown will appear with options to create a tablet or phone. The current software runs on an Android phone, so a phone is the best option to be selected from

this dropdown. Download the desired device and return to **Device Manager**. From **Device Manager**, select the run icon and the emulator should begin to run with the desired code.

1.3 Troubleshooting

The software team found no prevalent issues during development. Early concerns were had with handling the games, primarily the Sudoku game which had no parent design from the robot version of the app. These were primarily solved through more research and the increase in familiarity with the language of Flutter. The primary concern moving forward is the lack of development organization that would allow the project to increase in size. There is a need to improve this in some capacity.

Development tips would be first to improve the GitHub for ZhaoRobotLab. The first thing to develop is a README, which would allow developers to transition into the project easily. The README would contain content like this report, explaining the packages and environment required to run the software. In addition to this, GitHub should include a developer's guide to track progress in development. This would provide documentation of changes made and changes to be done. Information to include would be branches of the app and how branches connect or are being developed. Including branches would allow developers to work on independent features of the app without influencing the main code. With larger teams of software developers, this would prevent issues in implementing new code.

An alternative to GitHub would be Jira software. This web software is commonly used for larger projects of app development. Jira allows developers to be assigned specific tasks and review updates before publishing. Figure 4 shows an example of the Jira software. This shows the to-do, in-progress, in-review, and done assignments allowing developers to track the specific phases in development.

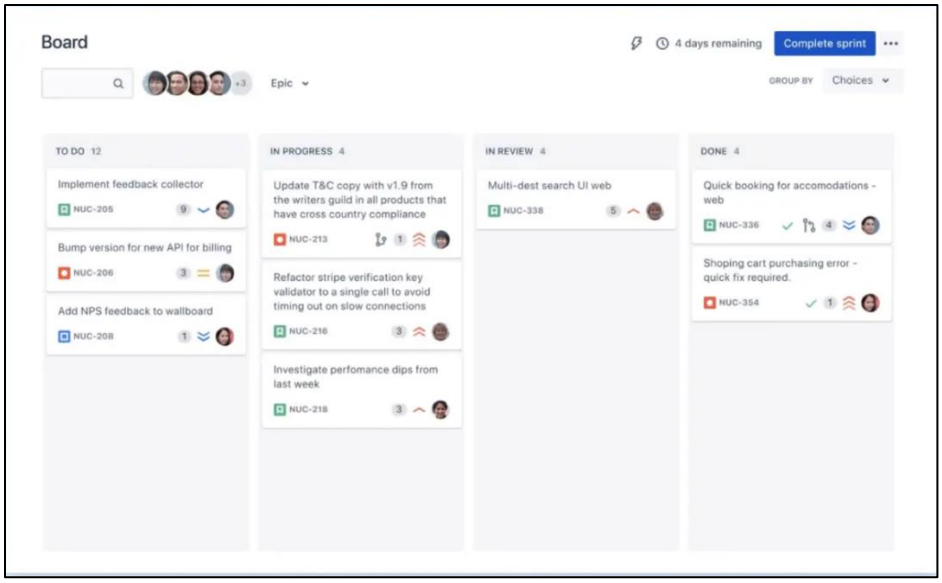

Figure 4: Example of Jira software.

2. Application Use Examples

This section will detail the usage of the application features. This will walk through how the features work and provide context to what process is expected to be used in the feature. Images are included for reference to the buttons that are mentioned in the text. All base features of the app can be reached through the home screen and the labeled buttons.

2.1 Games

To use the games in the app, the user will select the “games” icon from the home page. This will allow them to access the two games currently implemented. The user may select either a memory card game or sudoku. If the user selects a memory card game, the rules for the game will appear. When the user selects start game from here, the game will begin. For the memory card game, the score is calculated based on correct tries. The user will flip cards and try to match pairs of cards. The cards will remain shown if they are a correct set but will flip over if they are mismatched. The user will continue to play until all cards are matched. At the end of the game, the system will display a congratulatory message asking the user to play again or exit the game. Figure 5 shows the process of this game from the home page to the end of the game.

Figure 5: Process of playing the memory card game.

Sudoku can be played by selecting the sudoku game in the initial games menu. This will bring up a partially filled sudoku board. From this board, the user can input numbers to try to complete the game. Numbers can be input by selecting a square the selecting the desired number from the pad at the bottom. The number will be input if correct but will turn red if it is not the correct number. The user can delete a number by using the clear button if the number is incorrect. If the board seems too challenging, the user can select the reset button which will generate a new board. Once all squares are filled in during a game, a congratulatory message will appear along with the options to play again or exit the game. Figure 6 shows the sudoku game. The left image shows the new board and the middle image shows a misplaced number. The right side shows a new board after selecting reset.

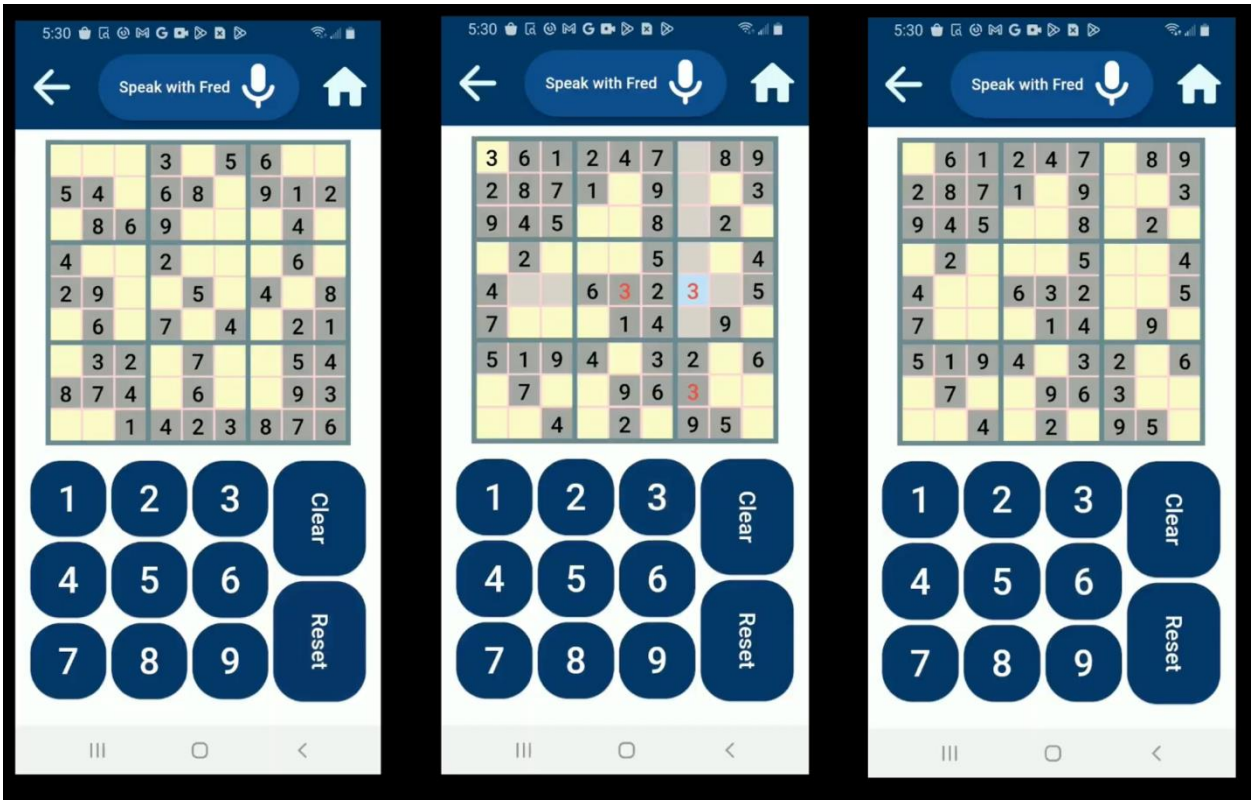

Figure 6: Sudoku gameplay with a new board and an in-play board.

2.2 **AI Chatbot**

To use the AI chatbot, the user will select the chatbot from the home screen. From here a similar interface to messages or phone-style text will appear. This includes a keyboard and text area for the user to input text into. When the user inputs text and sends a message, the message will appear in a bubble above allowing FRED to respond. The user can continue the conversation with this method. The user can alternatively use the voice chat feature to do this. Instead, the user will select the microphone at the top of the screen, which will activate the speech-to-text feature. This will automatically pick up voices so the user can immediately start talking. When the user finishes their statement or question, they can press the green button to input the message or press the red button to delete the message. If the message is input, the conversation will continue as usual. If the message is deleted, no changes will be made to the current conversation. FRED has a variety of responses but using more direct phrases and statements will likely lead to better responses. Figure 7 has the flow of the AI chatbot. The center images show the conversation while the right image shows what appears when selecting the microphone for speech-to-text.

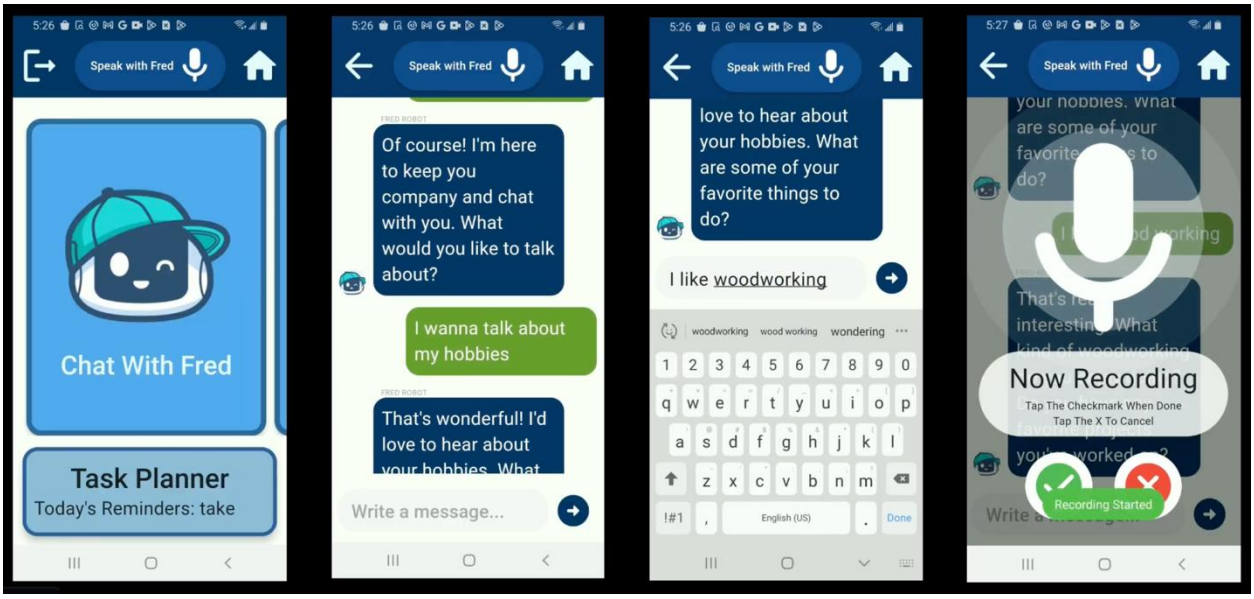

Figure 7: AI chatbot in use with both physical text and speech-to-text.

2.3 **Reminders**

To set a reminder, the user should select the reminders button from the home screens main menu. From here they will be given two options to either set a reminder or see the task planner. Choosing a set reminder will access the reminder setting page. On this page, there are three sections to set. The first is a description of the reminder. The user should input the name and description along with setting the type of reminder right below this input line. The type can be personal, appointment, or medication currently. The user has the option to set a duration for the reminder as well with the time dropdown. The user can then set the date of the reminder. This will be done using the toggle switches for up and down choosing the day, month, and year of the reminder. The user will then set the time with the hour, minute, and time of day as am or pm. These toggles are directly below the date toggles. When the reminder is complete, the user will select the set reminder button at the bottom which will finish setting the reminder. Figure 8 shows how to do this process. The flow of this will go from left to right with the reminder set notification indicating the completion of the reminder.

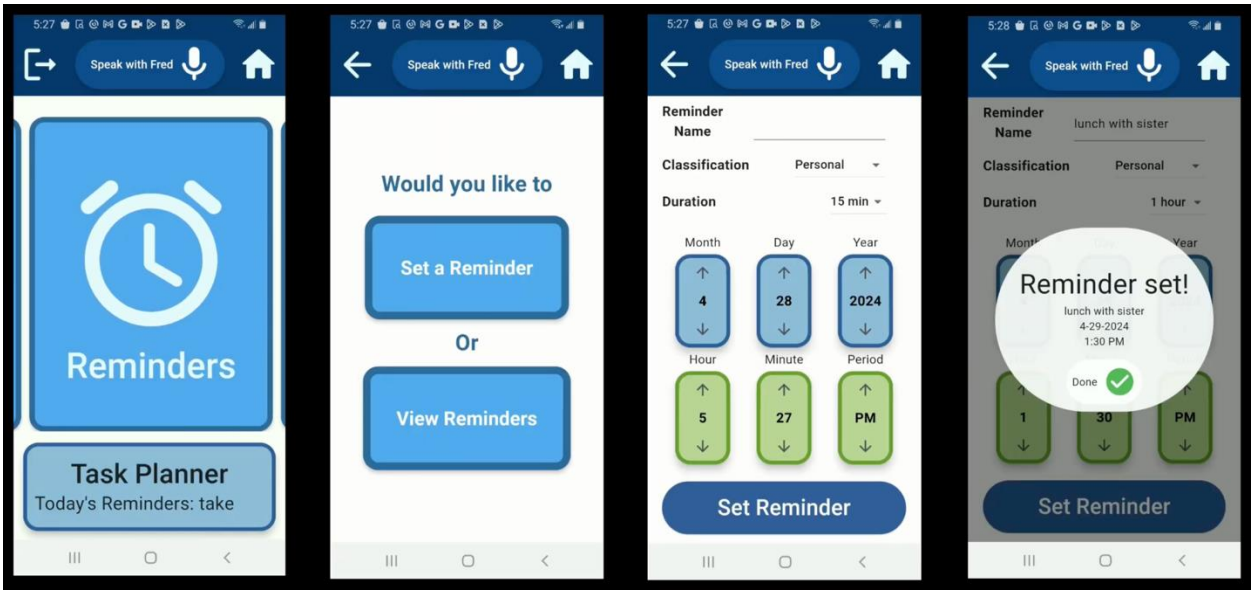

Figure 8: Process for setting a reminder in the app.

2.4 **Task Planner**

The task planner can be accessed through two methods. On the home screen, the user can select the reminders button from the main menu on the task planner button at the bottom of the screen. The reminders tab will take the user to the reminders page with two options. The user will select the task planner on this page instead of a set reminder. Alternatively, the task planner button on the home page will take the user directly to the reminders screen. On the task planner screen, the current day will appear with the tasks scheduled for that day. If a task is complete, there will be a checkmark in the adjacent box indicating it is done. If a user wants to look at a different view, they can select the day, week, or month view at the top. The week view will show the days on the left with the reminders of the day adjacent to it. Selecting one of these reminders will bring up the day view again with all the reminders that day. In the month view, the user can see the entire month. Each day that has a reminder set will have a dot on it. Selecting that day will bring up the day view where users can see all reminders for that day. Figure 9 shows the navigation for the task planner with each screen. When a task is selected, more information can be shown, such as in the second image from the left. Additionally, a user can see the number of tasks on a given day through the month view, and can see the length of the task in the weekly view.

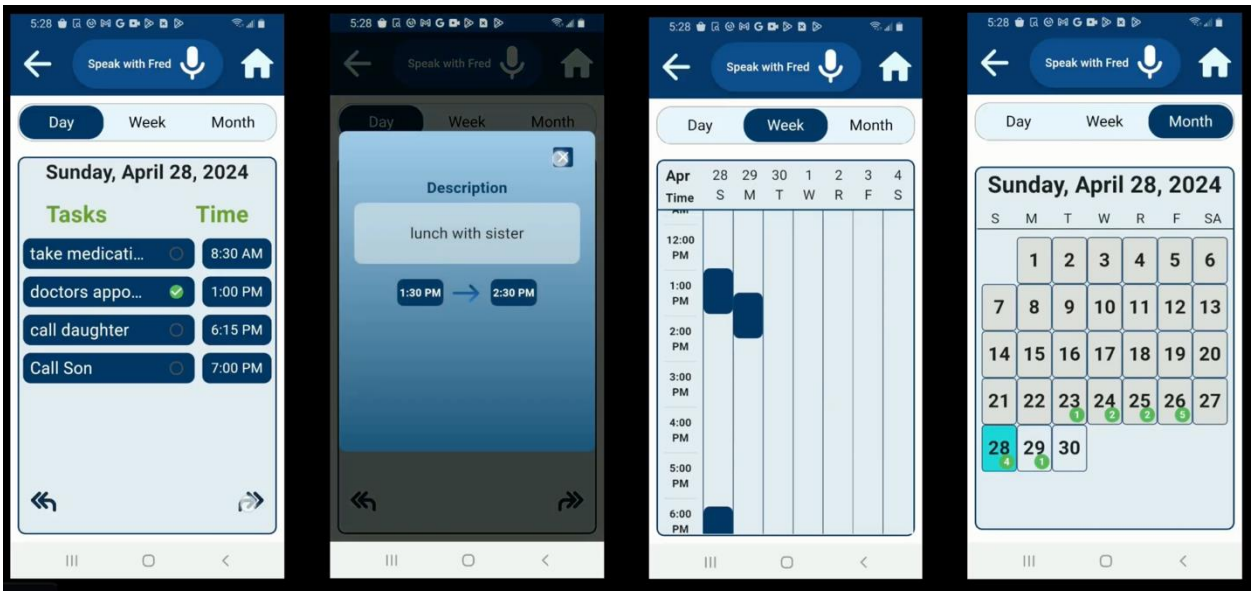

Figure 9: Task planner navigation.

3. SBIR

NOVI's client Dr. Zhao originally requested for an SBIR proposal to be drafted and submitted for this project. However, the client has changed his request to only include the following parts of the SBIR proposal described in this section as he has not created a company by which the SBIR proposal needs to be submitted. The following sections are written for the National Institute of Health's request for proposal PAS-22-196: Advancing Research on Alzheimer's Disease (AD) and AD-Related Dementias (ADRD) (R41/R42 Clinical Trial Optional).

3.1 Research Plan

The research plan component of an SBIR proposal is a critical section aimed at outlining the project's scientific or technical merit. It serves to persuade funding agencies that the proposed research is both innovative and feasible. In the context of the FRED App, this section aims to demonstrate to the NIH that the FRED App is scientifically rigorous, technically feasible and has the potential to yield significant innovation and impact. It aims to convince the reviewers of the project's merit and justify the allocation of funding resources. The NOVI team included this section because it serves as the main chunk of the SBIR proposal that NOVI can contribute to without Dr. Zhao's help, and it is the most practical section that Dr. Zhao can use should he choose to start a company and pursue funding.

3.2 Introduction

Fifty-five million people in the world suffer from some form of dementia, which translates to $1.3 trillion in global economic costs [1]. Fifty percent of these costs are attributed to informal caregivers (such as family members and close friends) who provide an average of five hours of care and supervision per day. In addition to the financial costs, there are significant emotional costs as well. A common side effect of Alzheimer's disease and related dementia (ADRD) that is not often discussed are feelings of loneliness and isolation, for people with the disease and caregivers alike. There is a need for an innovative and low-cost solution to ease the burden of care and enhance the lives of individuals with ADRD. To address this issue, team NOVI has done initial development on an app that aims to assist individuals with ADRD and their caregivers by providing them with the unique resources they need and proving the feasibility of the content. This app called the FRED App, includes two main user profiles: a primary user profile for the person with dementia and a caregiver profile for their caregiver, most likely a family member. This app is a stepping-stone to better treatment and support for this vulnerable population.

3.3 Innovation

The FRED mobile application proposes a novel solution to the ADRD epidemic present in the United States. The FRED app, developed using Flutter, combines innovative game functions and practical features designed to cater to the unique needs of early to middle-stage ADRD patients. Utilizing Figma for initial UI/UX design, the app ensures a user-centric experience, with the implementation seamlessly carried out in Flutter. OpenAI's advanced technology powers the chatbot function, integrating both text and speech interaction capabilities.

3.3.1 PWD Profile: Games

The game function encompasses two proven games— a memory card game and a sudoku-style math game— specifically tailored for ADRD patients. The memory card matching game will be a cognitive and memory-enhancing activity that will involve a set of face-down cards arranged in a grid. The objective will be to find matching pairs of cards by flipping them over two at a time. If a pair is found, then the cards will remain face-up; if not, they are flipped back face-down. The game continues until all pairs are successfully matched. Within this game, users can personalize their experience by uploading personal pictures for card images. The sudoku-style math game will be a logic-based number-placement puzzle that will consist of a range of square grid sizes broken down into smaller sub-grids. The objective will be to fill in each row, column, and sub-grid with the numbers 1 through the size of the grid, ensuring no repetition occurs in any row, column, or sub-grid. A partially completed puzzle will be presented to the player, with some numbers already filled in. The user will be tasked with logically deducing the correct placement of the remaining numbers. To enhance user support, the customizable FRED avatar and chatbot intervene if a user

is unresponsive for a specified duration, providing assistance and preventing frustration.

3.3.2 **Reminders**

Moving on, the reminder function will serve as a tool to help users organize and manage their tasks, events, and commitments. Both the primary user and the caregiver can set personalized reminders for various activities, such as appointments, meetings, or daily tasks. The feature will allow users to input specific details about the reminder, including the date, time, and any additional notes. Reminders can be delivered through various channels, such as SMS, push notifications, or even phone calls, depending on user preferences. This feature ensures that users stay on top of their schedules and responsibilities by receiving timely alerts and prompts, contributing to improved time management and overall productivity. Additionally, the flexibility to choose notification methods and the ability to set recurring reminders enhance the user experience, making the reminder app an indispensable tool for staying organized and meeting deadlines.

3.3.3 **Task Planner**

The task manager app feature will provide both primary users and caregivers with a comprehensive tool to plan, organize, and track their daily activities and responsibilities. Within the app, users along with their caregivers can create, edit, and prioritize tasks, ensuring a structured approach to their daily lives. The task manager will offer features such as list creation, due dates, and categorization, allowing users to tailor their organization methods to their preferences. In the context of collaborative usage, caregivers or other authorized users may contribute to the task planning, facilitating coordinated efforts in managing the user's schedule. The ability to mark completed tasks and visualize upcoming events in an easily accessible layout will enhance user productivity and time management. The task manager feature thus acts as a central hub for efficient planning and execution of daily routines, contributing to a streamlined and well-organized lifestyle.

3.3.4 **Chatbot**

FRED also has an assistive chatbot powered by OpenAI, which serves as a pivotal feature within the app, designed to cater to the unique needs of individuals with early-stage dementia and their caregivers. Leveraging cutting-edge speech-to-text technology, FRED seamlessly translates spoken words into text, facilitating effortless communication for users. Tailored to adapt to the distinct requirements of both dementia patients and their caregivers, FRED acts as a supportive companion, offering companionship, reminders, and assistance in daily tasks. For individuals with dementia, FRED provides gentle reminders for appointments, medication schedules, and engaging conversation to alleviate feelings of loneliness and confusion. On the caregiver side, FRED offers valuable support by providing information on dementia care, offering suggestions for activities, and serving as a resource for managing caregiver stress. Through its intuitive interface and

personalized interactions, FRED embodies our commitment to enhancing the lives of those affected by dementia, fostering connection, and providing invaluable assistance in navigating the challenges of the condition.

3.3.5 Caregiver Profile: Information/Courses

The “Courses” feature on the caregiver side of the app offers a comprehensive resource hub, providing access to a range of informative articles and courses aimed at enhancing the quality of care for individuals with dementia. Caregivers can explore various courses covering essential topics such as different types of care, transitioning between care stages, and engaging activities to keep the PWD occupied and stimulated. They can also access general knowledge in scientific articles chosen from reputable sources. Additionally, for caregivers seeking more specialized knowledge, we offer technical courses available behind a paywall, ensuring access to in-depth information and expertise. To further streamline the learning process, an AI chatbot is integrated into the platform, assisting caregivers in finding suitable courses based on their inquiries and providing valuable guidance along their caregiving journey. With the “Courses” feature, FRED empowers caregivers with the knowledge and resources necessary to provide optimal care and support for their loved ones with dementia.

3.3.6 Caregiver Profile: Loved Ones

The "Loved Ones" feature in the app provides caregivers with vital tools to monitor and support their loved ones with dementia. Offering real-time insights into their loved one's well-being, caregivers can track their current location and receive notifications if they travel beyond predefined boundaries, ensuring their safety. The feature also includes activity tracking, displaying the number of steps taken, and seamlessly syncing with Apple Watch for users who utilize this device. Caregivers can manage tasks and reminders, keep track of completed activities such as eating and medication intake, and promote adherence to care plans. A key component of the "Loved Ones" feature is the medical and activity notes section, facilitating communication among different caregivers by providing a centralized platform to document important information, including medication logs, charting data, and journal entries to monitor their loved one's health and progress over time. By consolidating these essential features into one accessible interface, caregivers can effectively coordinate care and ensure the well-being of their loved ones with dementia.

3.3.7 Caregiver Profile: Community

The “Community” feature serves as a vibrant hub for caregivers to connect, engage, and access valuable local resources. Through interactive maps, caregivers can easily locate nearby support services, including medical facilities, support groups, and dementia-friendly establishments, enhancing their ability to navigate their local community with confidence. The integrated events calendar keeps caregivers informed about upcoming workshops, seminars, and social gatherings

tailored to their interests and needs. Furthermore, the discussion boards provide a platform for caregivers to share experiences, exchange advice, and offer support to one another, fostering a

sense of community and solidarity. By leveraging technology to bridge geographical gaps, FRED's "Community Page" empowers caregivers to forge meaningful connections, access essential resources, and find solace in the shared journey of caring for loved ones with dementia.

3.3.8 Caregiver Profile: Self-Care

Finally, the "Self-Care" feature is designed to prioritize the well-being of caregivers, recognizing the importance of self-care in maintaining resilience and balance. Personal reminders prompt caregivers to engage in activities that promote physical and mental health, such as taking breaks and going for walks, fostering moments of rejuvenation amidst the demands of caregiving. Guided meditation sessions offer a tranquil retreat, providing caregivers with tools to manage stress and cultivate mindfulness. The journaling feature provides a reflective space for caregivers to process emotions, track their experiences, and celebrate personal achievements, fostering self-awareness and growth. Inspirational quotes and general tips serve as gentle reminders to nurture social connections, seek support when needed, and embrace moments of joy and gratitude. By integrating these self-care tools into our app, FRED empowers caregivers to prioritize their well-being, ensuring they have the strength and resilience to continue providing compassionate care to their loved ones with dementia.

3.4 State of the Art Comparison/Significance

The FRED app is entering a market that is relatively new and has not reached its full potential. There has been a growing emphasis on digital health solutions for ADRD patients, but there is still more that can be done. Some of the biggest apps in the market space include Lumosity [3] and MindMate [4]. Lumosity focuses on the brain training segment with games and exercises for the mind. They have gained millions of users due to their ability to use research-backed games to give people their mental workout each day. MindMate [4] promotes mind and body fitness. They include various games, workouts, recipes, and videos to give users some resources to maintain a healthy physical and mental lifestyle. These apps provide tools that can be beneficial to users, and they want to help people beyond the ADRD segment with their everyday brain functioning.

Additionally, there are also apps targeted towards caregivers, which is another facet of the FRED app. CaringBridge offers caregivers a platform to create personalized websites for sharing updates and coordinating support from their community, providing features for journaling, task management, and communication tools [5]. MediSafe Medication Management focuses on medication management, offering caregivers tools for creating medication lists, setting reminders, and receiving refill alerts to ensure adherence to treatment plans [6]. Inacare provides comprehensive support for caregivers of individuals with dementia, including features for tracking location, managing tasks, and accessing community resources, with a focus on addressing the

unique needs of dementia caregivers through personalized care plans and educational materials [7]. Each of these competitors offers valuable tools and resources to empower caregivers in their caregiving journey, addressing specific aspects of care management and support.

FRED distinguishes itself by offering both caregiver and patient profiles, facilitating seamless communication and connection between caregivers and patients. By integrating both profiles, FRED enhances the coordination of care and support, connecting caregivers to their loved ones with dementia more effectively than these apps do individually.

3.5 Technical Objectives

In the product development of the FRED app during Phase 1, the app software will be developed with three major technical objectives: functionality, security, and UI/UX Refinement. Once initial solutions to these objectives have been developed, the NOVI team will iterate and refine these solutions through rigorous user testing.

3.5.1 Functionality

The functionality of the main app features is key to creating a viable product. Table 2 lists features and subcomponents that will need to be coded in Flutter to have a competitive working prototype:

Table 2: Features necessary for a viable product

Features	
Games	• Memory card matching • Sudoku
Reminder	• Get reminder • Set reminder
Task Manager	• Daily view • Weekly view • Monthly view
AI Chatbot	• Speech to text • Text to speech
Courses/Information	• Activity levels • Selective information
Loved Ones	• Activity levels • Synced tasks/reminders • Synced notes across caregivers
Community	• Events page • Map of local resources • Discussion board
Self-Care	• Journal • Meditation • Inspirational quotes • Self-care reminders

3.5.2 **Security**

User security is a paramount concern in app development, necessitating careful consideration and robust testing to safeguard user data and privacy. Key aspects of ensuring user security during this stage in development include the implementation of secure authentication methods, protecting data during transmission and storage, and addressing potential vulnerabilities. The following security features and practices will need to be implemented to create a robust and trustworthy product that safeguards user information and instills confidence in the app's user base:

- Authentication mechanisms, including log-in and multi-factor authentication
- Secure transmission protocols (HTTPS) to encrypt data during communication between the app and the server
- Encryption of sensitive user data on the device
- Vulnerability and penetration testing using automated testing tools

3.5.3 **UI/UX Refinement**

Refining the UI/UX of the FRED app will be crucial for creating positive and engaging user interactions. The following steps will need to be taken during Phase I:

- Conduct user research to gather insights about preferences, behaviors, and pain points
- Streamline the app's navigation to make it intuitive and user-friendly, aiming for a clear and logical flow
- Establish a clear visual hierarchy to guide users through the app, using contrasting colors, font sizes, and spacing to emphasize important elements and direct attention to key actions
- Ensure the app is responsive and optimized for various devices and screen sizes
- Conduct A/B user testing with different design variations
- Ensure app accessibility

3.6 **Work Plan**

During the initial phase of the FRED app development, the focus will be on comprehensive user research. User research will be conducted rigorously through surveys, interviews, and the analysis of feedback. This thorough examination aims to gain a profound understanding of the target audience's preferences, behaviors, and pain points. Armed with these insights, the development team will prioritize coding essential features such as the card matching game, Sudoku game, reminder, task manager, and AI chatbot, as well as the following main pages of the caregiver side: Courses, Loved Ones, Community, and Self-Care. Simultaneously, there will be a strong focus on initial security implementation to safeguard user data and privacy. This will involve integrating secure authentication methods, employing encrypted transmission protocols, and conducting thorough vulnerability and penetration testing.

Following the establishment of core functionality and security measures, the team will transition to refining the app's UI/UX. This phase encompasses streamlining navigation, establishing a clear visual hierarchy, ensuring responsiveness across devices, and conducting A/B user testing to gather valuable feedback. Accessibility features will also be implemented to cater to diverse user needs. Embracing an iterative development approach, the team will engage in periodic user testing sessions to identify usability issues and gather insights for further refinement.

As the app progresses through iterative development and user testing, the finalization and deployment phase will ensure that all standards in functionality, security, and user experience are met. A strategic plan for the app's market launch, including app store submissions, marketing strategies, and user outreach, will be meticulously crafted. Post-launch, continuous monitoring will address emerging issues, and user feedback will guide subsequent updates and enhancements, ensuring that the FRED app remains robust, secure, and user-friendly in the dynamic landscape of user expectations and technological advancements.

3.7 Commercialization Plan

The commercialization plan is specifically for the SBIR for Phase II. Therefore, only certain sections can be completed at this stage. This section of the SBIR will include information about the importance of the SBIR, marketing research and strategy, and competition.

3.8 Value of SBIR, Expected Outcomes, and Impact

The FRED app is designed to be multi-functional to help bring structure and support to those affected by ADRD. The PWD side includes memory games, a simple math game, and a task manager. These functions can be used to help stimulate users' brains while also giving them a way to plan out their day so that events are not forgotten. Users can have access to the FRED avatar, which is a robot designed to help brighten the day of any user. FRED uses AI to help as an interactive notification system and friendly helper during any in-app activities. Furthermore, the app's caregiver side includes features such as support networks, monitoring tools, educational resources, stress management strategies, and care coordination. These features will provide caregivers access to a community and information about their loved one(s). Millions of lives worldwide are affected by ADRD, and the FRED app has the potential to influence and better the lives that encounter it. The app's features aid families that need help when adjusting to a new lifestyle that comes with ADRD. To accomplish this goal, the SBIR grant money will enable Dr. Zhao to commercialize the app. The income that is generated by the app will be used to fund his research lab. The FRED app was initially taken from a project that involved an assistive robot. That market space has been slowly growing with robots that can use speech recognition to aid consumers. This app is a starting point for a project that could develop into an assistive robot in the future. Dr. Xiaopeng Zhao, who began the FRED project, will start to look for ways to integrate the FRED app into an actual assistive robot that could be brought to market. The functionality of a mobile or in-house assistant leaves room for many more opportunities within the FRED features. The FRED software is meant to be a stepping-stone for future projects that can find better ways to ease the lives of people living with ADRD or related parties.

3.9 Marketing Research

This section of the report discusses the FRED app's target market and market opportunity, which caters to people with mild to moderate dementia and their caregivers. It highlights the growing demand for dementia care products due to increasing awareness and the rising number of dementia cases globally. Additionally, this section outlines the specific challenges faced by informal caregivers and the potential for caregiver apps like FRED to address these needs through features such as support networks, monitoring tools, educational resources, stress management strategies, and care coordination.

3.9.1 **PWD Side**

The target market for the FRED app is people with mild to moderate dementia who can still utilize their smartphones daily and live at home, either with a caretaker or alone. Alzheimer's disease has disturbing effects on the memory and cognitive function of a person and negatively impacts daily activities. Along with the disease's progress, there is also an increase in patient assistance. Dementia care products are aids designed to help make dementia patient’s lives easier [8]. The global dementia care products market is valued at US $29.1 million. The market is anticipated to grow at a compound annual growth rate (CAGR) of 6.9% to reach US $56.7 million by 2033. The dementia care product industry is continuously observing significant growth due to the increased awareness of disease management, increased sales prospects, advancement in devices, and improvement in existing devices. The rising number of dementia cases over the globe generates a market opportunity for dementia care products. According to the World Alzheimer Report 2015, more than 10 million new cases of dementia occur each year worldwide, which implies a vast consumer base worldwide for these dementia care products.

A specific dementia care product is dementia care apps. While 80% of people with dementia live at home, as dementia progresses, the likelihood of institutionalization increases, which is against the wishes of many patients and their family members [9]. Dementia care apps can provide critical support and potentially improve the quality of life of people with dementia and their family caregivers [10]. Mobile device usage among Americans 65 or older has dramatically increased, with almost half utilizing smartphones. There was a 60% increase in American older adults using the Internet between 2000 and 2019. With the increased usage of mobile devices, apps have been developed to support people with dementia, such as help with memory, safety, and daily activities. Studies show that mobile assistive apps can help enhance the quality of life by helping them complete tasks and promote independence. While several apps already in the App Store or on Google Play are targeted towards people with dementia, these apps are limited. Despite the capacity to assist in dementia care and help reduce care costs, there is a lack of knowledge in understanding the needs of people with dementia relating to these care apps. Furthermore, another study found that the quality of the apps is minimally acceptable. Therefore, there is a market opportunity for the FRED app as it will be designed and iterated based on continuous user testing to provide greater value to users.

3.9.2 **Caregiver Side**

The goal of the FRED app is to ease dementia and dementia-related diseases on both the caregiver and the patient. Therefore, NOVI developed an additional side of the app that specifically caters to informal patient care. In other words, the target market for the FRED (caregiver side) will be friends or family who directly care for the person with ADRD and who are not receiving financial compensation. There are currently over 16 million Americans providing unpaid care for people

with Alzheimer’s or other dementias [11]. Additionally, a study performed in 2023 found that unpaid caregivers provide an estimated 18.4 billion hours of care, valued at $350 billion [12].

There are five common problems informal caregivers face when taking care of PWD: psychological morbidity, social isolation, physical morbidity, and financial difficulties [13]. To help alleviate some of the burdens caregivers face, caregiver apps have become a hot issue. The caregiver app market has substantially expanded over the past years due to the personalized care and efficiency of apps [14]. The caregiver app market is incredibly diverse, ranging in assistance with scheduling, monitoring health conditions, providing educational resources, and enabling communication between caregivers and care recipients. However, a study found that most of the apps on the marketplace for caregivers are not meeting their needs as they are difficult to navigate, lack customization, and are missing information. From this study, there were 5 sub-themes in features that expressed to be important to caregivers: connections to other supports, recordkeeping and monitoring, information and tips, strategies to manage stress, and coordination of care. The FRED app includes all of these features. Therefore, there is a market opportunity for the FRED app regarding the caregiver side.

3.10 **Marketing Strategy**

The marketing strategy for the FRED app focuses on reaching individuals with mild to moderate dementia, caregivers, and patients' families. Leveraging a multi-platform approach, the company aims to tailor its messaging across diverse channels. Strategic partnerships with healthcare and dementia-related communities will be established to build credibility and widen its reach. Active engagement within various social media support groups will facilitate the direct promotion of the app, emphasizing its benefits in dementia care. Additionally, the app will use Google Search Ads to target people seeking dementia-related care products. The company plans to participate in Alzheimer's Walks across the United States, setting up booths to showcase the app's features and advantages. Additionally, the FRED app intends to pay for advertising on podcasts such as The New Normal, On Your Own, or The Dementia Podcast. This holistic strategy intends to engage specific audience segments, foster trust, and position the app as a valuable solution within the dementia care landscape.

3.11 **Competition**

The following passage outlines the competitive landscape of the FRED app broken down into the PWD and caregiver sides. It details the functionalities of the apps such as cognitive stimulation, memory aid, and task management provided by apps like Lumosity, Constant Therapy, and It's Done!

3.11.1 **PWD Side**

Several mobile apps can aid people with dementia: Lumosity, Constant Therapy, Mind Mate, and It's Done! The apps currently on the marketplace either aid in cognitive stimulation or memory aid. For example, Luminosity provides over 40 brain-training activities for memory, speed, logic, problem-solving, and math. The It's Done! app is a task management system that provides reminders for daily tasks. While mobile applications have similar features as the FRED app, there are currently no apps on the marketplace that provide cognitive stimulation and memory aids. Therefore, the FRED app provides a point of differentiation to consumers as it is an all-in-one resource. Figure 10 shows FRED's positioning compared to other dementia care apps in the marketplace.

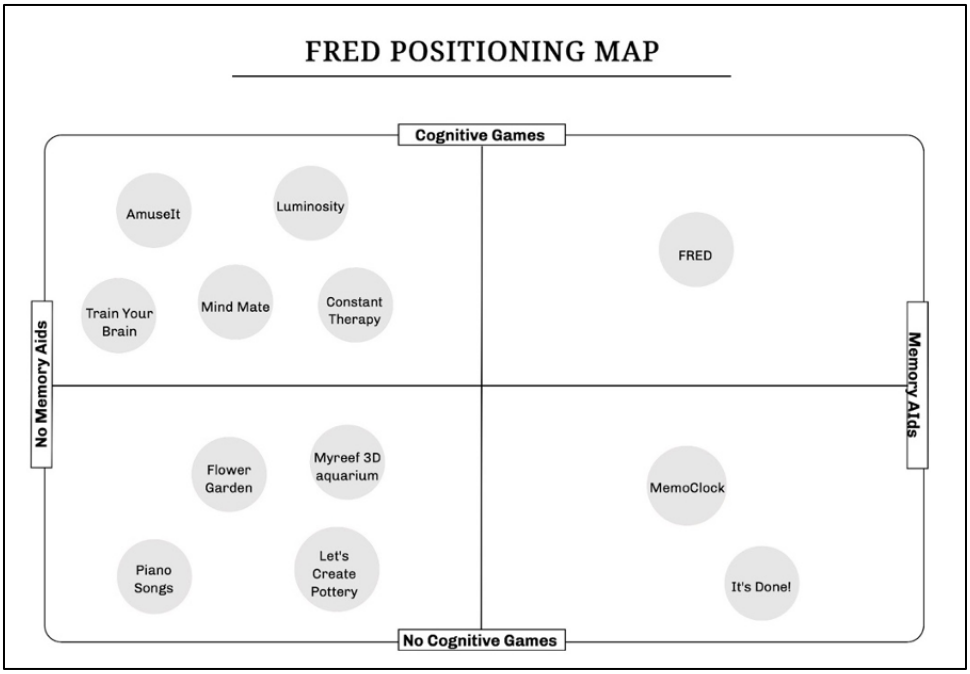

Figure 10: PWD FRED Positioning Map

3.11.2 **Caregiver Side**

There are several mobile apps on the market to help caretakers: Carely, Lotsa Helping Hands, Insight Timer, Medisafe, Alzheimer’s Caregiver Buddy, and It’s Done! [15]. These apps aid in connection, task management, and information. Carely is an app that creates a caretaker network for all caregivers who are involved with the PWD; it is a communication and coordination platform to help coordinate the caregiver's responsibilities. Insight Timer is a meditation app that can help manage anxiety and stress and improve the sleep of caretakers. Medisafe is an additional app that helps to make medication less challenging by sending out medication reminders and daily alerts;

it also tracks the refills and expiration dates and will send notifications whenever the prescriptions run low. Furthermore, the Alzheimer's Caregiver Buddy, developed by the Alzheimer's Association, is an app that provides information about dealing with daily activities, forgetfulness, concentration and wandering, and more [16]. While there are mobile applications that have similar features as the FRED care side, there are currently no apps on the marketplace that provide information, community, self-help, and a task management system. Therefore, the FRED care side will have a point of differentiation in the market.

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