VCU College of Engineering

Project #302 and SON - Patients

Preliminary Design Report

Prepared for

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Executive Summary

The executive summary highlights the key points of the document. While your advisor(s) and sponsor are expected to read the document in detail, others may only read the summary looking for a brief overview of the report. Casual readers may look at the summary to decide if they would like to continue reading. Some, more senior decision makers (e.g. executives), may read the summary to help make decisions regarding the future of the project (e.g. continuation, financing, resource allocation, etc.). It is important that all readers get a complete sense of the project, including purpose, primary objectives, design requirements, deliverables, work done to date, and timeline, among other required components provided in a table of contents. Summaries should be considered as "stand-alone" containing a complete account of the essential points of the document in chronological order of the document. Particular focus should be placed on the first sentence in order to draw readers in and should explicitly include the "who, what, and why" of the project. The executive summary is usually between half a page and a full page.

Note: The Executive Summary should be updated between major reports as more knowledge is acquired and understanding of the project expands. For example, when submitting Preliminary Design Report in December 2024, make sure you update this page to reflect the progress on the project since the submission of Project Proposal in early October 2024.

This report outlines the ongoing development of a tablet-based application aimed at improving patient engagement for elderly, low-income patients enrolled in the Mobile Health and Wellness Program (MHWP), a project initiated by the VCU School of Nursing. The primary objective of this application is to enable patients to easily access their health data, such as blood pressure and blood sugar levels, after their clinic visits, remind them of health goals, and help them prepare for future appointments. The app is being designed to address the needs of a demographic with low health and technology literacy by prioritizing simplicity, accessibility, and ease of use.

The project's current scope focuses on the development of a prototype application that will pull data from a custom-built database. This database will integrate health metrics and patient goals, providing a user-friendly interface that empowers patients to stay engaged with their healthcare. The design requirements include compliance with HIPAA and WCAG 2.1 standards, ensuring data privacy and accessibility for individuals with disabilities. The project will follow a structured development timeline, with key milestones that include the creation of a high-fidelity prototype, data collection through patient interviews, and the submission of a Fall Design Poster.

This report provides a comprehensive overview of the project's goals, deliverables, and milestones, as well as the design and technical specifications required to create a functional and user-centric application. The project is expected to improve health outcomes by enabling patients to take a more active role in managing their health between clinic visits.

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Section A. Problem Statement

The Mobile Health and Wellness Program (MHWP), initiated by the VCU School of Nursing, operates wellness clinics at nine community sites across Richmond, offering health assessments, monitoring, and coaching (Haerin, 2024). One major gap in the current system is the absence of a patient-friendly interface for reviewing past visits and preparing for upcoming appointments. Both patients and clinicians fill out surveys in a database during their appointments, but there is no easy way for patients to recap this information.

Target Problem
For many elderly patients—particularly those with low income and limited health and technology literacy—staying engaged with their health data between visits is a challenge. Our project, CS-25-302, aims to create a solution that enables these patients to access their previous visit information, health metrics, and goals in a simple, digestible format. This will help them better prepare for their meetings with clinicians and stay involved in managing their health.

Scope of the Problem
The need for a user-friendly interface is widespread, particularly within the community MHWP serves, where patients are elderly and have high medical complexity. These patients may have low literacy and little experience with technology, creating additional barriers to effectively engaging with their own health data. By creating a tablet-based application, we can empower patients to stay involved in their health, leading to improved clinical outcomes and overall well-being.

Project Goals

- **Primary Objective**
  To develop a prototype tablet application that enables patients to review health data from their last visit, remind them of their goals, and prepare them for their upcoming clinician meeting. This app will pull data from the student-created database, focusing on displaying relevant health metrics (such as blood pressure and blood sugar) and tracking health goals.
- **Design Considerations**
  - **User Interface (UI) and Experience (UX)**: Given the user demographic, the app needs a simple interface with large fonts, color-blind-friendly palettes, and basic vocabulary (*School of Nursing*). Additionally, the app should have a print option utilizing CSV format for patients who prefer paper records.
  - **Patient Empowerment**: Patients should leave the clinic with a clear sense of their health progress, ideally with a printed “player sheet” summarizing their data and goals.

Research Background and Prior Solutions

The CS-25-302 project fits into the broader context of mobile health applications aimed at improving patient engagement in healthcare. Existing solutions like MyChart focus on sharing lab results, but few cater specifically to elderly, low-income populations with limited health literacy. MWHP currently uses Redcap, however, we have been asked to create a new database specifically for the program, which we will use in fetching information.

A review of similar mobile health initiatives shows that effective patient engagement tools must prioritize simplicity and accessibility. For instance, the “All of Us” program demonstrates the value of patient data transparency, but without proper tailoring to specific user groups, such systems can be underutilized. Our solution aims to build on these lessons by developing a tool that directly addresses the specific needs of MHWP patients.

Stakeholders

- **Patients**: The primary beneficiaries, elderly individuals with complex medical needs and low technology literacy.
- **Clinicians**: Healthcare providers at MHWP clinics, who will benefit from patients being better prepared for their appointments.
- **MHWP Researchers**: While not the focus of this project, researchers may also indirectly benefit as better-prepared patients can provide clearer data for research purposes.

Next Steps

- **Focus Group Research**: Meet with sponsors to see what information patients would most like to see on their application.
- **Prototype Development**: Use tools like Figma to mockup the user interface.
- **Create Database**: Work with other teams to create and design the database.

Section B. Engineering Design Requirements

This section describes the goals and objectives of the project, as well as all **realistic constraints** to which the design is bound. It is meant to provide a structure that helps to formulate the problem. Design requirements are often derived from client or stakeholder needs. They may consider benchmarking against or improving on currently available solutions, providing novel techniques or design solutions, integration with existing components, systems, or equipment, required codes and standards, general observations of the problem space, etc. Describe how the requirements provided below were researched and decided upon. Common design requirements often include considerations of the design efficacy, cost, safety, reliability, usability, and risk, among others.

Note: The design requirements should be revisited between major reports to ensure that the design objectives and constraints still accurately reflect the client needs and project goals and to make sure that the team is on track to meet all goals and objectives.

Note: The codes and standards section is not required for the Project Proposal, but is required for all subsequent reports. This section should be comprehensive and thorough, requiring a significant research effort.

B.1 Project Goals (i.e. Client Needs)

The objective of our project is to develop a mobile application for patients enrolled in the Mobile Health and Wellness Program. This app aims to enhance patient engagement by allowing them to review their health goals and concerns prior to their appointments. By facilitating this review, patients can better utilize appointment time to focus on current concerns and make measurable progress. To achieve this objective, we will focus on the following goals:

- Enable clinicians to access patient information through a unique identifier.
- Create a database, allowing our app to easily access data related to the Mobile Health and Wellness Program.
- Integrate health-related goals and data from the database.
- Present health data, such as blood sugar and glucose levels, in a format that is accessible and comprehensible for a diverse patient population.
- Design an intuitive and visually appealing user interface that enhances ease of navigation.

B.2 Design Objectives

The design objectives for this project focus on creating a tablet-based application for elderly patients with low health and technology literacy. These objectives are SMART—Specific, Measurable, Achievable, Realistic, and Time-bound—to ensure the project stays on track and meets user needs.

Objective #1:

The design will present health data in an accessible format.

- The app will display key health metrics (e.g., blood sugar, blood pressure) clearly, using large fonts and color-blind-friendly palettes to accommodate the needs of the target demographic.
- This objective is measurable by evaluating patient feedback on ease of use and clarity.
- Achievable given the available resources, including access to the created database.
- Realistic because it aligns with the project's scope, which focuses on user-friendly design for low-literacy patients.
- This objective will be completed within the first two development cycles.

Objective #2:

The design will integrate with the patient database to pull and display patient data.

- The app will securely connect to the created database to extract patient information, including past visit data, goals, and health metrics.
- This objective will be measured by the successful implementation of data retrieval functions and their display in the app.
- Achievable with the current team’s expertise in database integration and software development.
- Realistic because the application takes from already stored data, and the task is to format and display it.it.
- This will be achieved by the third development cycle.

Objective #3:

The design will allow patients to review their health goals and past visit information before appointments.

- The app will feature a section that highlights health goals and progress, and another section displaying past visit information, thus helping patients prepare for their next meeting with a clinician.
- Measured by user interaction data, assessing how often this section is accessed and used by patients.
- Achievable through the planned development and integration phases, ensuring this functionality is tested early.
- Realistic because it addresses a core user need—staying engaged with health between visits.
- This objective will be met by the final development cycle, with user testing included.

Objective #4:

The design will enable printing of a summary of health metrics/goals and past visits.

- The app will provide a print option that generates a CSV format summary of the patient's health data, catering to patients who prefer paper records.
- This will be measured by the successful implementation and testing of the print function.
- Achievable within the project timeline, leveraging existing tools for CSV generation.
- Realistic because it builds on existing functionality and addresses a common patient need.
- This feature will be included in the final release phase.

These objectives ensure the app meets both technical requirements and user needs, empowering patients to engage more effectively with their health data and clinicians.

B.3 Design Specifications and Constraints

This section outlines the design specifications and constraints that must be met for the app to be acceptable and successful. Each specification or constraint corresponds to specific design objectives and is measurable and testable.

1. Design must accommodate users with low technology and health literacy, using a minimum font size of 16 pixels and touch target sizes of at least 44 x 44 pixels.

2. Design must comply with HIPAA standards, ensuring patient data is encrypted.

3. Design must operate on tablet devices running iOS and Android, optimized for screen resolutions between 1024 x 768 and 1920 x 1080 pixels.

4. Design must generate a PDF summary ("player sheet") formatted for letter size (8.5 x 11 inches) within 5 seconds of the user's request.

5. Design must conform to WCAG 2.1 Level AA guidelines, ensuring a contrast ratio of at least 4.5:1 for visual content and keyboard navigation for interactive elements.

6. Design must allow for updates and bug fixes to be deployed within 24 hours of identification without significant downtime.

B.4 Codes and Standards

The design of the app will adhere to various specific codes and standards that ensure quality, safety, usability, and compliance. Below is a detailed list of the relevant codes and standards as they pertain to the design:

- HIPAA Compliance: The app must comply with the Health Insurance Portability and Accountability Act (HIPAA), which provides federal standards for the protection of patient health information. This compliance ensures that patient data is securely stored and transmitted, maintaining privacy and security (Stephen Beer.).
- WCAG 2.1: The app will follow the Web Content Accessibility Guidelines (WCAG) 2.1, which provides recommendations for making web content more accessible to people with disabilities. This standard emphasizes the need for designs that accommodate users with low vision, motor impairments, and other disabilities, ensuring inclusivity (*Web content accessibility guidelines (WCAG) 2.1)*.
- BCNF (Boyce-Codd Normal Form): the database that we will create will follow the normalization rules of BCNF.
- S.M.A.R.T. Goals: The design will incorporate Specific, Measurable, Achievable, Relevant, and Time-bound (S.M.A.R.T.) goals to track patient progress. This approach aligns with usability standards, presenting patient data in a user-friendly manner that promotes engagement.
- ADA Compliance: The app will comply with the Americans with Disabilities Act (ADA), which sets forth requirements to ensure that digital content is accessible to individuals with disabilities. This compliance will further enhance usability for elderly and low-income patients (*Americans with disabilities act*).

These codes and standards are critical to the development of the app, as they provide guidelines and requirements that enhance usability, safety, security, and compliance with relevant regulations. By incorporating these standards into the design specifications and constraints, the project aims to deliver a reliable and effective tool for patients**.**

Commented [ih1]: Optional for us to include text to speech for people who are blind or unable to read

Section C. Scope of Work

The project scope defines the boundaries of the project encompassing the key objectives, timeline, milestones and deliverables. It clearly defines the responsibility of the team and the process by which the proposed work will be verified and approved. A clear scope helps to facilitate understanding of the project, reduce ambiguities and risk, and manage expectations. In addition to stating the responsibilities of the team, it should also explicitly state those tasks which fall *outside* of the team's responsibilities. *Explicit bounds* on the project timeline, available funds, and promised deliverables should be clearly stated. These boundaries help to avoid *scope creep*, or changes to the scope of the project without any control. This section also defines the project approach, the development methodology used in developing the solution, such as waterfall or agile (shall be chosen in concert with the faculty advisor and/or project sponsor). Good communication with the project sponsor and faculty advisor is the most effective way to stay within scope and make sure all objectives and deliverables are met on time and on budget.

C.1 Deliverables

The project deliverables are those things that the project team is responsible for providing to the project sponsor. They are the things that are to be produced or provided as a result of the engineering design process. Some deliverables might include a specific number of alternative designs, required analyses to prove the design meets specifications, detailed machine drawings, functional diagrams or schematics, required computer code, flow charts, user manuals, desktop models, and functioning prototypes. A design "proof of concept" is not specific and should be more clearly defined. Academic deliverables include the team contract, project proposal, preliminary design report, fall poster and presentation, final design report, and Capstone EXPO poster and presentation. Provide a bulleted list of all agreed upon project deliverables.

In order to mitigate risks associated with the completion and delivery of the project deliverables, provide an outline of the most potentially disruptive, foreseeable obstacles. Some important issues to discuss with the design team, sponsor, and faculty advisor include the following:

- What deliverables require access to campus? Which/how many students regularly access campus and are physically available to complete tasks?
- What work can be done remotely? What resources might be needed in order to ensure that remote work can be completed effectively (e.g. software licenses, shared drives/folders, etc.)?
- What deliverables require ordering from third-party vendors? Will any components potentially required extended lead times? What can the team do in order to mitigate potential supply chain disruptions?

- **Fall Design Poster**
    - Created in Microsoft Powerpoint
    - Includes at least five design variations
    - Designed using Figma
- **Preliminary Design Report**
    - Developed in Microsoft Word
- **Final UI Prototype**
    - Created using Figma
- **Application Minimum Viable Product (MVP)**
    - Built with React Native
    - Key Requirements:
        - Ability to query database or call API
        - Capable of receiving and displaying information from database
        - Health metrics displayed in a simple, visual format
        - Implemented security measures to protect patient data
- **Final Application**
    - Developed using React
    - Additional Features:
        - Patient data can be converted into a PDF
        - Printing compatibility for PDF files
        - Accessibility Settings:
            - Adjustable font size
            - High-contrast mode
- **Final Documentation**
    - Created in Microsoft Word
    - Includes instructions for clinicians on app usage and patient guidance
- **Final Design Report**
    - Written in Microsoft Word
- **Capstone EXPO Abstract**
    - Drafted in Microsoft Word
- **Capstone EXPO Poster**
    - Created using Microsoft Powerpoint

C.2 Milestones

Milestones	Description	Timeframe	Date of Completion
Figma Prototype	Create high-fidelity prototypes in Figma, including UI components for the	2 weeks	Oct 27, 2024

	app and accessibility features.		
Data Collection (Patient Interviews)	Conduct interviews with clinic patients to gather insights on their health data needs and app functionality.	2 weeks	Nov 3, 2024
Poster Design	Design the Fall Design Poster in Quarto, incorporating Figma visuals and key design choices.	2 weeks	Nov 10, 2024
Final Touches for Fall Design Poster	Finalize the Fall Design Poster with updated data, feedback, and final MVP prototype visuals.	1 week	Nov 15, 2024
Fall Design Poster Submission	Submit the Fall Design Poster showcasing the MVP, Figma prototype, and patient feedback.	1 week	Nov 15, 2024
Feedback Integration	Collect feedback from stakeholders (patients, faculty advisor, sponsor) and iterate on the MVP and prototype.	1 week	Nov 17, 2024
Design Report	Work on the Design Report, documenting prototype variations and design/feature decisions.	2 weeks	Dec 11, 2024
Final Repo	Completion of the entire project	6 weeks	April 24, 2025
Final Report	Completion of the final report	1 week	May 4, 2025

C.3 Resources

Resources needed for project completion should be listed at the proposal stage. These resources can either be purchased within the Project Budget, or provided by the project sponsor. Some examples are: hardware such as HPCs or servers, software such as IDEs, data analysis

platforms or version control systems. Access to cloud computing services may also be necessary to scale certain procedures. Additionally, databases containing operational data for testing, as well as libraries or APIs relevant to predictive analytics and machine learning may be required.

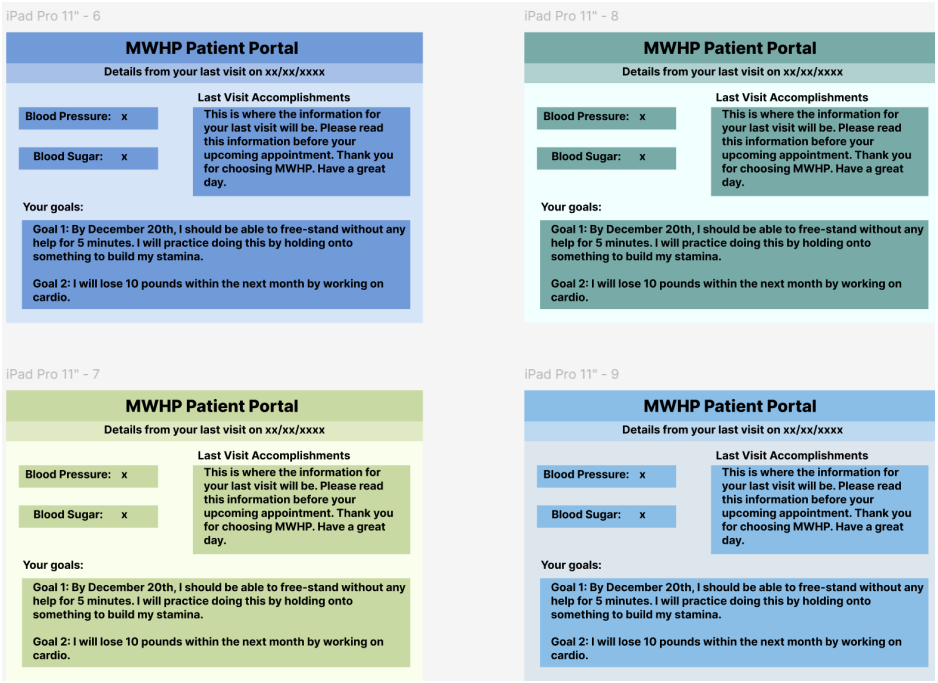
It is unlikely that any paid resources will be needed for our project. Some tools we plan to use in our project include GitHub, React Native (allow for flexible web and mobile development), Expo (for deploying), and Figma (for prototypes). We will be creating our own database with fake information about clients. We may require funds for API keys if we decide to use ChatGPT for text-to-speech or speech-to-text.

Section D. Concept Generation

Upon beginning to design our app, we were quickly scheduled to visit the MHWP site on the Monroe Park Campus. Before 2 members of our group – Prakash and Angela – visited the site, Prakash created various possibilities for what the app could look like in Figma. These variants consisted of different colors and layouts of health goals and statistics.

Different screens within the app:

Different color variants:

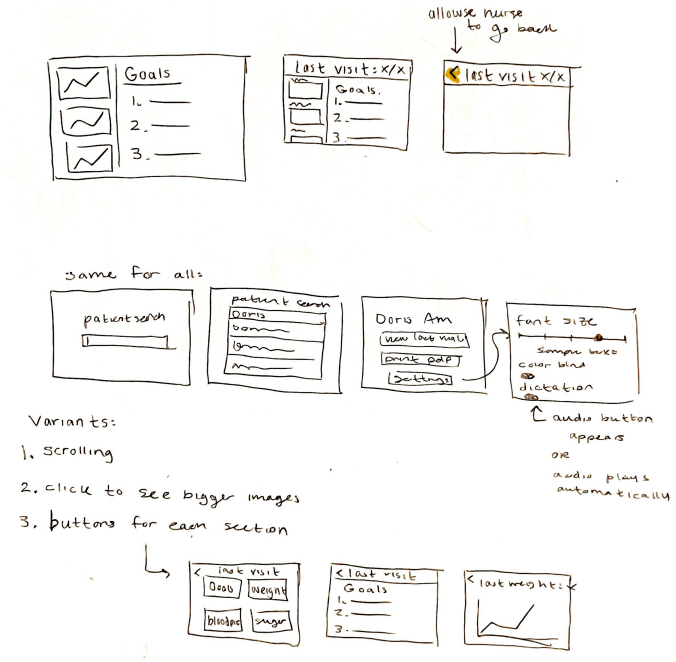


At the MHWP site, Prakash and Angela showed these mockups to a wide range of MHWP patients, asking for their opinion on the colors, layout, and information displayed within the app. They also asked patients what additional features they would like to be included.

There seemed to be a lack of consensus on what colors should be used for the app. Patients also didn't have any complaints about the layout of the application. However, many patients wanted more statistics – specifically their weight – to be displayed within the app. We also learned that most patients don't have phones, and thus whatever navigation that is used for the app should be easily navigable to those with less technological experience. Additionally, they mostly liked the idea of providing the last visit information in PDF format.

We then met as a group to discuss different ideas for the structure of our app, keeping in mind simplicity and visibility. Rachel and Angela worked to create some thumbnails for possible user interface variants.

App thumbnails:



Some considerations we made:

- Goals can vary in length, so there should be some ability to scroll if the goal exceeds the page.
- Health statistics should also be displayed as graphs to show the change over time.
    - We discussed whether this should be a line graph or bar graph, but we ultimately decided on a line graph as it's best suited for time-based data.
- There will need to be a search screen for clinicians to search for a patient.
- There should be a settings screen where clinicians can adjust font size, color, and dictation settings for patients.
    - Alternatively, each page could have a dictation setting, removing the need for a dictation setting.
- There should be a button that allows the information to be printed out as a PDF.

With regards to the main page, there were four variants we considered:

1. Scrolling – All information is displayed on one page that can be scrolled through.
2. Button navigation – Each metric (blood sugar, blood pressure, weight, and health goals) are their own buttons on a home page. Clicking those buttons will navigate the user to pages specific to those metrics.
3. Graph buttons with pop ups – There's one main page containing small graphs of health statistics and health goals listed. Upon clicking the graph buttons, larger versions of the graph pop up.

4. Graph buttons with full versions on the side – There are two pages, one for health statistics and one for health goals. The health statistics page consists of smaller graph buttons displayed on one side, and larger versions of the selected graph displayed on the right.

Section E. Concept Evaluation and Selection

Decision matrix:

	Scrolling	Button navigation	Graph buttons with pop ups	Graph buttons with full versions on side
Ease of Use	0.8	0.6	0.5	0.5
Accessibility	0.8	0.7	0.6	0.4
Error Tolerance	0.9	0.3	0.7	0.9
Task Efficiency	0.2	0.2	0.9	0.7
Weighted Total	0.76	0.53	0.61	0.57

Given the above table, we have defined four main criteria. They include Ease of Use, Accessibility, Error Tolerance, and Task Efficiency. Ease of Use refers to how straightforward the application is to use for the user, which is particularity important for us since our demographics are elderly who don't have much experience working with technology. Next, we have Accessibility, which refers to how inclusive the UI is to those with visual impairments or impaired motor skills. Features like button size and default text size have been taken into account. Third, we included an Error Tolerance criterion for having our app be robust in terms of the elderly not finding ways to "get lost" or frustrated with the app. Lastly, we chose Task Efficiency as we want for actions within the app to be fairly fast – once a user gets to know the app, all exchanges will be fairly fast.

We assigned each criteria a value between 0 and 1 based on how well the UI variant fulfills that criterion. Then, for each variant, we calculated its weighted total using the following weights:

Ease of Use -> 40%
Accessibility -> 30%
Error Tolerance -> 20%
Task Efficiency -> 10%

Upon evaluating our UI variants, we have determined the following ranking and scores for them:

1. Scrolling – 0.76
2. Graph buttons with pop ups – 0.61
3. Graph buttons with full versions on side – 0.57
4. Button navigation – 0.53

The scrolling navigation takes first place due to its simplicity and accessibility. All content is consolidated on a single page, requiring only scrolling from users, making it straightforward for patients to interact with. However, there is a potential usability concern: it might not be immediately apparent that the page can be scrolled. The structure resembles a PDF layout, which significantly simplifies PDF creation. The primary drawback of this approach is that accessing various elements requires scrolling through the page, which could be time-consuming compared to other navigation methods. Despite this, its simplicity and compatibility with PDF formatting make it a strong contender.

The graph buttons with pop-ups rank second due to their efficiency. All information is accessible from a single page without requiring scrolling, relying instead on pop-ups activated by buttons. However, this design poses challenges in ease of use. Users may not immediately recognize the graph buttons as clickable, and it may not be intuitive how to close the pop-ups once they appear. This could lead to error-prone interactions, especially if users struggle to exit the pop-ups. Despite these concerns, the design offers quick and efficient access to information, making it a valuable option to consider.

In third place is graph buttons with full versions on the side. This variant closely resembles the previous one but avoids pop-ups, improving error tolerance. Clicking a graph button displays the corresponding graph on the side, rather than occupying the entire screen. This design is more straightforward for users to navigate and reduces potential frustration. However, displaying the graphs on the side reduces their size, potentially impacting the visibility and readability of data. Another downside is that health goals are displayed on a separate page, which could complicate navigation for some users. While it addresses some usability issues, these trade-offs place it third.

The button navigation approach ranks last despite its strengths in accessibility and ease of use, thanks to the larger buttons provided for navigation. Issues arise with efficiency, as users must return to the home page to navigate between sections, which could lead to confusion or frustration, particularly if a button is mis clicked. For the limited amount of information on each page, this navigation system feels inefficient. Consequently, this design was not pursued further when creating mockups in Figma.

From here, we decided to create Figma mockups of the top three design that we will present to our MHWP sponsors during the spring semester. They liked all three designs, but they preferred the graph buttons with full versions to the side, as it required they believed it was the most user friendly. They suggested some improvements to our design, such as adding buttons on the graph so users can better understand their metrics. Our faculty sponsor, Dr. Leonard, also suggested changing the icons on the buttons to the left.

Section F. Design Methodology

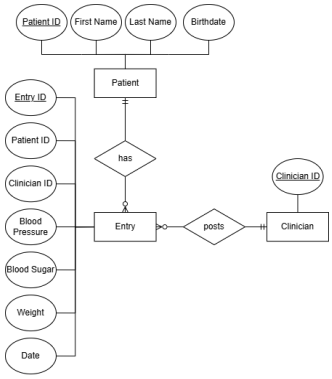
Provide a detailed explanation of the methods that will be used to help evaluate, improve, and evolve the design through the iterative engineering design process. Consider that ultimately, the final design must be verified and validated to ensure that it meets all of the previously developed and listed design objectives and specifications. Verification ensures that the design meets all specification, while validation confirms that the design functions as intended such to meet the client's needs. While it is common for initial design concepts to first be evaluated using simplified design criteria and metrics, the chosen design should be advanced, and later verified, using engineering calculations, computational models, experimental data, and/or testing procedures.

Use this section to describe any underlying physical principles and mathematical equations that govern the design. Provide details of any computer-aided modeling techniques used to evaluate the design including the software used, prescribed boundary conditions, and assumptions. Include a detailed description of any experimental testing methods including required testing equipment, test set-up layout, data acquisition and instrumentation, and testing procedures. If one or more prototypes is to be produced and tested, provide a detailed description of how each will be evaluated.

Note: The contents of this section are expected to vary from project to project. Subsections may be appropriate for providing details of analytical, computational, experimental, and/or testing methods. Some potential subsections that may be included in this section are provided. While critical design equations may be provided here, lengthy mathematical derivations may be included in an appendix. Validation procedures are critical and all projects should address such topic.

F.1 Computational Methods

1. **UI/UX Prototyping:**
    - Figma was used to create high-fidelity wireframes for:
        - The dashboard displaying key health metrics.
        - Screens for goal tracking and visit history.
        - Print summary functionality for exporting data.
    - Prototypes were tested with stakeholders for iterative improvements.
2. **Database Design:**
    - A relational database schema was modeled using ERBs, comprising tables for patient profiles, clinicians, and entries



- Indexing and normalization techniques were applied to improve query performance and maintain data integrity.

F.2 Experimental Methods

1. **User Testing:**
   - Went to the Mobile Health and Wellness Program to survey patients and clinicians
     - Evaluated color schemes, current features, and accessibility (font sizes, “Print to PDF” function, etc.)
     - Metrics/surveys were evaluated and considered
   - Will create the app and re-issue surveys once next iteration is completed

F.3 Architecture/High-level Design (example subsection)

1. **Application Layers:**
   - The application is divided into two main layers.
     - Firstly, we have our front-end which we have a finalized Figma prototype for. This is to be implemented in the Spring semester using React Native.
     - Secondly, we have a SQL database designed with all of the necessary entities, relations, and attributes needed to communicate between the patient side and the clinician side.

F.5 Validation Procedure

Describe how the design team will validate that the final design meets the client's needs. This section should include a plan to meet with the client towards the end of the project to discuss final design details and demonstrate a prototype, experimental test, and/or simulation results. Provide a relative time frame for this validation to occur (e.g. "mid-March" or "early-April"). Include a brief discussion on how client feedback will be captured, such as a formal survey, interview, or observation notes of the client using the prototype. It may also include plans to solicit feedback from other stakeholders and/or potential users.

Our team plans to have a fully functional application complete by mid to late March that includes all the features in the Figma prototype. Once the application is complete, we will first show the application to the patients to gain user-feedback about recommendations for the app. After this interview with the patients, we will complete one final iteration before showing the final product to Dr. Wendte and Dr. Leonard.

Final recap: Our validation procedure followed our initial plan. We showed off our Figma prototype to our clients (MHWP patients and clinicians). Next, we made changes and asked for their opinions once again. Next, we created the project and discussed with the patients/clients. This iterative approach led us to create a project that satisfied the clients' needs.

Section G. Results and Design Details

Use this section to highlight the major results of the design methodology described above including important analytical, computational, experimental, modeling, assembly, and testing results. This section should be one of the most substantial sections of the report showcasing all of the hard work and effort that went into the completion of the final design and delivery of the project deliverables. Show how the identified problem was solved.

Highlight the prominent features of the final design through analysis results, modeling, drawings, renderings, circuit schematics, instrumentation diagrams, flow and piping diagrams, etc. to show that the design functions as intended and meets all design objectives and constraints. Overview designs such as dataflow diagrams, process flow, swim lane diagrams, as well as presentation-layer designs (e.g. storyboards for front-ends) should be included here. Detailed designs such as database designs, software designs, procedure flowcharts, or pseudocode should be included here. Support computational and experimental results with key plots and figures. All supporting figures should be clearly labeled and annotated to highlight the most important points of the figure (i.e. explicitly point out what the reader should focus on or understand about the image).

Note that while all results should be used to help inform design decisions, not all results may be necessary to include in the main body of the report. Extraneous supporting results (e.g. graphs, data, design renderings, drawings, etc.) that are not necessary for presenting the fundamental findings can be placed in one or more appendices. Detailed documentation of each program module can be provided as appendix.

G.1 Modeling Results (example subsection)

Our modeling efforts focused on two areas:

1. **User Interface Modeling**:
   - Created multiple Figma prototypes exploring different navigation approaches
   - Developed a decision matrix to evaluate UI design variants:
     - Scrolling design emerged as the top-performing concept (score: 0.76)
     - Prioritized ease of use, accessibility, and error tolerance
   - Prototype iterations included:
     - Layout considerations for health goals and statistics
     - Accessibility-focused design elements
   - Created a full application using React Native that was based on the Figma mockups.

2. **Database Design**:

- Developed a relational database schema using Entity-Relationship Diagrams (ERDs)
- Implemented normalization techniques (BCNF) to ensure data integrity
- Created tables to store:
    - Patient profiles
    - Clinician information
    - Health metrics and visit history

G.2 Experimental Results (example subsection)

Experimental research was conducted through:

1. **Patient and Clinician Interviews**:
    - Conducted on-site interviews at the Mobile Health and Wellness Program (MHWP)
    - Key findings:
        - Patients desired additional health statistics (e.g., weight)
        - Confirmed need for PDF export functionality
        - Identified navigation challenges for users with low technological literacy
2. **Design Iteration Feedback**:
    - Tested multiple UI design concepts with target users
    - Gathered insights on:
        - Color preferences
        - Information display
        - Ease of navigation
    - Refined design based on direct user input

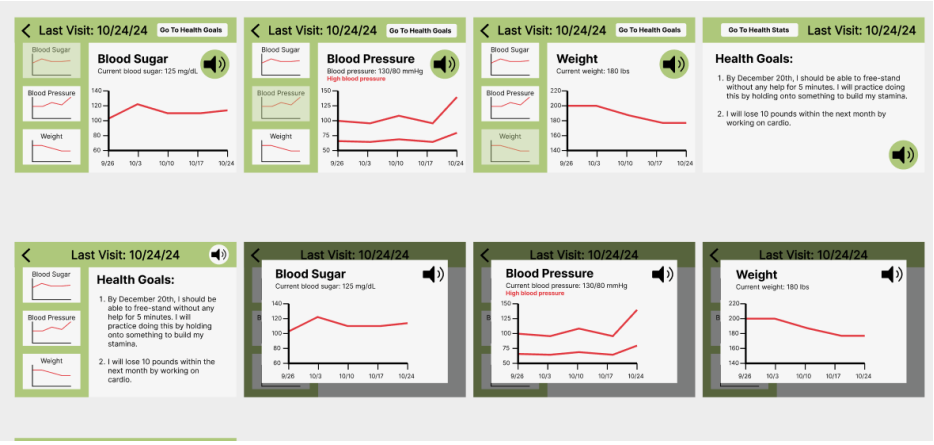
G.3 Prototyping and Testing Results (example subsection)

Prototype Development:

- Created high-fidelity Figma prototypes
- Developed four navigation concept variants:
    - Scrolling design

- Button navigation
- Graph buttons with pop-ups
- Graph buttons with full versions on side

G.4. Final Design Details/Specifications (example subsection)



The team indicates they are leaning more towards the second option with the graph buttons and pop-ups but will make a final decision in collaboration with the project sponsor. This approach of evaluating multiple concepts and seeking stakeholder input demonstrates a thoughtful, user-centric design process.

Technological Stack:

- Prototyping: Figma
- Development: React Native
- Database: Custom SQL database + API
- Deployment: Expo

Note that while the design constraints and specifications may have provided minimum or maximum values, or ranges or values, that the design needed to meet, the final design specifications should be listed here showing that the required design values were met. A list of final design details can also be included demonstrate fulfillment of the design objectives.

Note: Preliminary results should be included in the Preliminary Design Report to show the progress made of the selected design concept to-date. This section should be updated for the

Final Design Report to include documentation of all of the work that was completed on the project throughout the entirety of the academic year.

Section H. Societal Impacts of Design

In addition to technical design considerations, contemporary engineers must consider the broader impacts that their design choices have on the world around them. These impacts include the consideration of public health, safety, and welfare as well as the potential societal, political/regulatory, economic, environmental, global, and ethical impacts of the design. As appropriate for the project design, discuss how each of these considerations influenced design choices in separate subsections. How will the design change the way people interact with each other? What are the political implications of the design? Does the technology have the potential to impact or shift markets? Does the design have any positive or negative effects on the environment? Don't forget to consider unintended consequences such as process or manufacturing byproducts. What impacts might the design have on global markets and trade? Are there any ethical questions related to the design?

While it is hard to forecast the various impacts of a technology, it is important to consider these potential impacts throughout the engineering design process. When considered during the early stages of the design phase, consideration of these impacts can help determine design objectives, constraints, and specifications and help drive design choices that may mitigate any potential negative impacts or unintended consequences.

Note: A minimum of 4 of these design considerations, including the consideration of public health, safety, and welfare, are required for the Preliminary Design Report while a section for all considerations must be included in the final design report.

Provide a list of all design safety features and provide a brief description of each. Discuss the potential effects the design may have on public health, safety, and welfare. References to the codes and standards previous provided and the organizations that produced them may be summarized or referenced here.

H.1 Public Health, Safety, and Welfare

Our app has the ability to allow patients to be better prepared for their appointments, which in turn, allows them to stay on-track about health goals, appointments, etc.

- HIPAA Compliance: The application ensures that all patient data is securely stored and transmitted, adhering to HIPAA regulations to protect sensitive health information.
- Accessibility Standards: The app follows WCAG 2.1 guidelines, ensuring that it is usable by individuals with visual impairments or other disabilities.
- Simple Navigation: Designed with large fonts, clear labels, and intuitive layouts to reduce cognitive load, particularly for patients with low technology literacy.

H.2 Societal Impacts

The app helps underprivileged populations, allowing them to work and better themselves

- Reduction in Health Disparities: The app's focus on simplicity and accessibility targets underserved populations, including elderly, low-income individuals.

H.3 Political/Regulatory Impacts

- Healthcare Regulations: Compliance with HIPAA ensures that patient data is protected, building trust with users and aligning with healthcare policies.

H.4. Economic Impacts

- Missed Appointments: With the app's appointment reminder function, patients will have a better time working with their schedules and be able to save money if they miss an appointment and are charged any sort of fee.
- Time Saved for Clinicians: The app's overall purpose is to prepare the patient before their appointment. With this, a clinician can save some time by not explaining everything from the past session. This allows for the clinician to meet with more patients

H.5 Environmental Impacts

- Reduction in Paper Usage: Since we are using tablets to present the information, we are slightly cutting down on paper usage. The users do have the option to opt for a paper option, but tablet-based reviews are preferred.

H.6 Global Impacts

- Scalability: We are hopeful that other clinics will look at our model and also adopt a similar practice of using our app or another version of it to prepare their patients for appointments.

H.7. Ethical Considerations

- Data Privacy: The app is designed with regulations like HIPAA in mind to ensure patient/ethical safety.
- Serving Underprivileged Communities: We have designed the app in a very simple manner to allow for the underserved (non-tech-savvy) community to engage with the app.

Section I. Cost Analysis

This project has not incurred any direct monetary expenditures, as it relies solely on the dedication and expertise of our team to create a meaningful tool for elderly patients. Rather than focusing on profit, we are committed to contributing our time and skills for the betterment of our community.

Our application, designed to help elderly patients review past visit information, emphasizes accessibility and ease of use. The development process will include front-end design using React Native and back-end design with the creation of a database to store and organize patient information. To ensure the application's usability and effectiveness, we have developed detailed prototypes using Figma. These prototypes serve as a foundation for front-end development and reflect our dedication to creating an intuitive, user-centered design tailored to the needs of elderly patients. All design, development, and testing efforts have been carried out by our team without external costs.

If this project were to transition to a commercial product, future cost considerations would include hosting services for the database, licensing fees for software tools, and labor for ongoing maintenance and updates. However, at this stage, our primary goal is to deliver a solution that improves the lives of our users, demonstrating our commitment to community-focused development. This section will be updated with any additional costs or estimates as the project progresses.

Section J. Conclusions and Recommendations

The engineering design process for this project was marked by iterative development, collaborative problem-solving, and meaningful stakeholder engagement. Our team began with a clear objective: to design an accessible and user-friendly application for clinicians and patients in the MHWP program to monitor and share health metrics effectively. Starting with conceptual sketches and low-fidelity prototypes created in Figma, we explored various layouts, color schemes, and navigation options. Patient interviews provided essential insights, highlighting the need for features such as weight tracking, PDF export functionality, and accessibility settings like adjustable font sizes and high-contrast mode. These insights drove the design's evolution, leading to a functional prototype tailored to user needs.

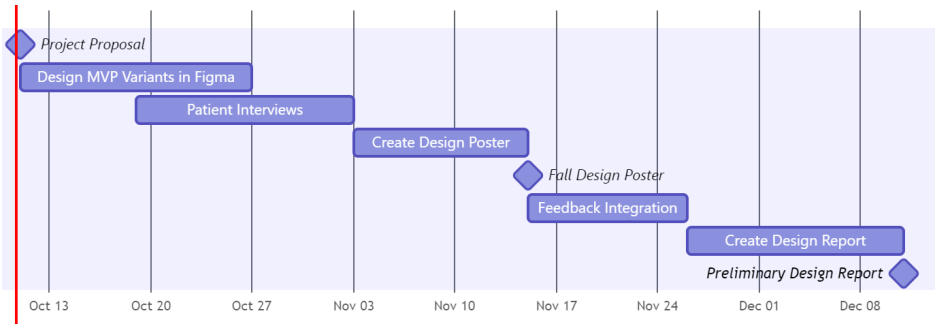
Our final design goal includes key features that align with the project's goals. The user interface prioritizes clarity and accessibility, offering high-contrast mode. Health metrics are visualized through line graphs to track changes over time, and a PDF export feature enables clinicians to easily share patient data. Button-based navigation simplifies usability, ensuring that patients with limited technological experience can navigate the app seamlessly. Clinician tools, including search functionality and dictation features, enhance the application's practicality in supporting health tracking and communication.

This process revealed valuable lessons, particularly the importance of user feedback in shaping design decisions. Early engagement with MHWP patients highlighted features not initially considered, such as the preference for weight metrics and the ability to export data. We also encountered challenges in balancing user preferences, such as color schemes, while adhering to accessibility standards. Despite these obstacles, the team's collaboration and focus on functionality over aesthetics ensured the project's success.

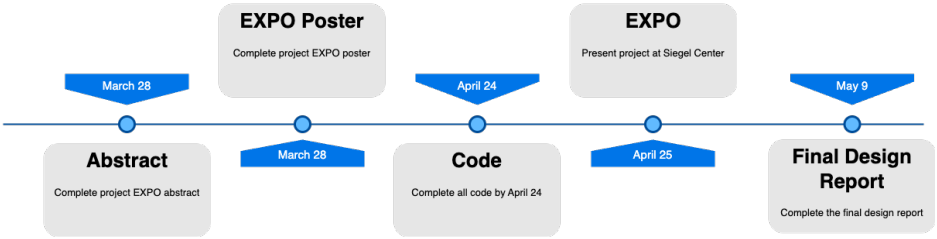
While the final design achieves the primary objectives, there are opportunities for further advancement. Future iterations could include additional health metrics, predictive analytics, and expanded accessibility features. Extending compatibility to web and tablet interfaces would also broaden the application's usability. Security enhancements, particularly strengthening data encryption to meet healthcare standards like HIPAA, are another key area for improvement. This project establishes a solid foundation for future teams to build upon. Major milestones, such as a high-fidelity prototype, patient feedback integration, and an MVP developed in React Native, have or will be completed, but the timeline may not allow for the previously mentioned potential improvements, which can be completed by future teams.

Appendix 1: Project Timeline

Fall Timeline:



Spring Timeline:



Appendix 2: Team Contract (i.e. Team Organization)

Copy and paste the content from the completed Team Contract here starting with Step 1 of the Team Contract and including all content following the 'Contents' list.

Step 1: Get to Know One Another. Gather Basic Information.

Task: This initial time together is important to form a strong team dynamic and get to know each other more as people outside of class time. Consider ways to develop positive working relationships with others, while remaining open and personal. Learn each other's strengths and discuss good/bad team experiences. This is also a good opportunity to start to better understand each other's communication and working styles.

Team Member Name	***Strengths each member bring to the group***	***Other Info***	***Contact Info***
Isaiah Hill	Organized, detail-oriented, great communicator, creative	Just finished internship at SEO content creation and about to start a coding bootcamp for front-end development	hillis@vcu.edu
Rachel Farzan	Organized, detail-oriented, conscientious	Double major in art and computer science; internship at AARP where learned Agile methodologies	farzanrl@vcu.edu
Angela Tran	Quick learner, ambitious, communication	In a VIP – software for social good. Creates affordable software for clients	tranan7@vcu.edu

Prakash Chatlani	Organized, quick learner	Had an internship where learned good software engineering practices	chatlanipr@vcu.edu

Other Stakeholders	***Notes***	***Contact Info***
Dr. John Leonard - Faculty Advisor	*Available on Thursdays (no classes that day)*	*Email: jdleonard@vcu.edu* *Discord: jleonard99*
Dr. Lana Sargent	*Has the Mobile Health and Wellness Program (MHWP) on Thursday mornings*	Email: lsargent@vcu.edu
Jered Wendte	*N/a*	wendtej@vcu.edu

Step 2: Team Culture. Clarify the Group's Purpose and Culture Goals.

Task: Discuss how each team member wants to be treated to encourage them to make valuable contributions to the group and how each team member would like to feel recognized for their efforts. Discuss how the team will foster an environment where each team member feels they are accountable for their actions and the way they contribute to the project. These are your Culture Goals (left column). How do the students demonstrate these culture goals? These are your Actions (middle column). Finally, how do students deviate from the team's culture goals? What are ways that other team members can notice when that culture goal is no longer being honored in team dynamics? These are your Warning Signs (right column).

Resources: More information and an example Team Culture can be found in the Biodesign Student Guide "Intentional Teamwork" page (webpage | PDF)

Culture Goals	***Actions***	***Warning Signs***
Accountability/Equal Contributions	- Task distribution (Jira) - Progress checks during meetings (Jira)	- Student does not do their tasks/work - Student does not update Jira board
Attendance	- Set reminders about meetings - Communicate	- 2 unexcused absences
Responsiveness (text – 24 hours; discord – 48 hours)	- Enable notifications for Discord - Mention (@) people for responsiveness - Text through phone number	- Student gets a warning for no responsiveness - 3 warnings and then have a student group conversation

Step 3: Time Commitments, Meeting Structure, and Communication

Task: Discuss the anticipated time commitments for the group project. Consider the following questions (don't answer these questions in the box below):

- What are reasonable time commitments for everyone to invest in this project?
- What other activities and commitments do group members have in their lives?
- How will we communicate with each other?
- When will we meet as a team? Where will we meet? How Often?
- Who will run the meetings? Will there be an assigned team leader or scribe? Does that position rotate or will same person take on that role for the duration of the project?

Required: How often you will meet with your faculty advisor advisor, where you will meet, and how the meetings will be conducted. Who arranges these meetings?
See examples below.

Meeting Participants	***Frequency*** ***Dates and Times / Locations***	***Meeting Goals*** ***Responsible Party***
Students Only	As Needed, On Discord Voice Channel	Update group on day-to-day challenges and accomplishments
Students Only	Every Thursday at 2:30pm in library	Actively work on project, discuss goals
Students + Faculty advisor	As needed – will join in our Thursday meetings when necessary	Update Dr. Leonard on progress and ask any questions
Project Sponsor	*Meet once a month;* *Will have three meetings in the coming two weeks:* *Meeting 1 - individual team meetings*	*Update project sponsor and make sure we are on the right track*

	Meeting 2 - redcap overview for all *Meeting 3 - site visit*	

Step 4: Determine Individual Roles and Responsibilities

Task: As part of the Capstone Team experience, each member will take on a leadership role, ***in addition to*** contributing to the overall weekly action items for the project. Some common leadership roles for Capstone projects are listed below. Other roles may be assigned with approval of your faculty advisor as deemed fit for the project. For the entirety of the project, you should communicate progress to your advisor specifically with regard to your role.

- **Before meeting with your team**, take some time to ask yourself: what is my "natural" role in this group (strengths)? How can I use this experience to help me grow and develop more?
- **As a group,** discuss the various tasks needed for the project and role preferences. Then assign roles in the table on the next page. Try to create a team dynamic that is fair and equitable, while promoting the strengths of each member.

Communication Leaders

Suggested: Assign a team member to be the primary contact for the client/sponsor. This person will schedule meetings, send updates, and ensure deliverables are met. – Rachel

Suggested: Assign a team member to be the primary contact for faculty advisor. This person will schedule meetings, send updates, and ensure deliverables are met. – Prakash

Common Leadership Roles for Capstone

1. **Project Manager:** Manages all tasks; develops overall schedule for project; writes agendas and runs meetings; reviews and monitors individual action items; creates an environment where team members are respected, take risks and feel safe expressing their ideas.
   Required: On Edusourced, under the Team tab, make sure that this student is assigned the Project Manager role. This is required so that Capstone program staff can easily identify a single contact person, especially for items like Purchasing and Receiving project supplies. - Prakash

2. **Logistics Manager:** coordinates all internal and external interactions; lead in establishing contact within and outside of organization, following up on communication of commitments, obtaining information for the team; documents meeting minutes; manages facility and resource usage. - Isaiah
3. **Financial Manager:** researches/benchmarks technical purchases and acquisitions; conducts pricing analysis and budget justifications on proposed purchases; carries out team purchase requests; monitors team budget. - Isaiah
4. **Systems Engineer:** analyzes Client initial design specification and leads establishment of product specifications; monitors, coordinates and manages integration of sub-systems in the prototype; develops and recommends system architecture and manages product interfaces. - Angela
5. **Test Engineer:** oversees experimental design, test plan, procedures and data analysis; acquires data acquisition equipment and any necessary software; establishes test protocols and schedules; oversees statistical analysis of results; leads presentation of experimental finding and resulting recommendations. - Rachel
6. **Manufacturing Engineer:** coordinates all fabrication required to meet final prototype requirements; oversees that all engineering drawings meet the requirements of machine shop or vendor; reviews designs to ensure design for manufacturing; determines realistic timing for fabrication and quality; develops schedule for all manufacturing. - Angela

Team Member	***Role(s)***	***Responsibilities***
Rachel	Test Engineer Sponsor Communication Leader	- oversees experimental design, test plan, procedures and data analysis - acquires data acquisition equipment and any necessary software; establishes test protocols and schedules - oversees statistical analysis of results; leads presentation of experimental finding and resulting recommendations. - Communicates with sponsor
Prakash	Project Manager Faculty Advisor Communication Leader	- Manages all tasks - develops overall schedule for project - writes agendas and runs meetings - reviews and monitors individual action items - creates an environment where team members are respected, take risks and feel safe expressing their ideas. - Communicates with faculty advisor
Isaiah	Logistics Manager Financial Manager	- coordinates all internal and external interactions - lead in establishing contact within and outside of organization, following up on communication of commitments, obtaining information for the team - documents meeting minutes - manages facility and resource usage

		- researches/benchmarks technical purchases and acquisitions - conducts pricing analysis and budget justifications on proposed purchases - carries out team purchase requests - monitors team budget.
Angela	Systems Engineer Manufacturing Engineer	- Ensures the project fulfills the project's specifications - analyzes Client initial design specification and leads establishment of product specifications - monitors, coordinates and manages integration of sub-systems in the prototype - develops and recommends system architecture and manages product interfaces. - oversees that all engineering drawings meet the requirements of machine shop or vendor - reviews designs to ensure design for manufacturing - determines realistic timing for fabrication and quality - develops schedule for all manufacturing

Step 5: Agree to the above team contract

Team Member: Prakash Chatlani *Signature: Prakash Chatlani*

Team Member: Isaiah Hill *Signature: Isaiah Hill*

Team Member: Angela Tran *Signature: Angela Tran*

Team Member: Rachel Farzan *Signature: Rachel Farzan*

References

Provide a numbered list of all references in order of appearance using APA citation format. The reference page should begin on a new page as shown here.

[1] *Americans with disabilities act*. DOL. (n.d.). https://www.dol.gov/general/topic/disability/ada

[2] Haerin. (2024, July 10). *Senior UI/UX Design Guide: Creating user-friendly interfaces for older adults*. Medium. https://medium.com/@leehrhr/senior-ui-ux-design-guide-creating-user-friendly-interfaces-for-older-adults-96f6e5f9d5d2

[3] *School of Nursing*. Mobile Health and Wellness Program - School of Nursing - Virginia Commonwealth University. (n.d.). https://nursing.vcu.edu/practice-and-community-engagement/mobile-health-and-wellness-program/

[4] Stephen Beer. (n.d.). *12-Step HIPAA-Compliant Website Checklist for 2024*. Clarity. https://www.clarity-ventures.com/services/hipaa-compliant-websites#1.0

[5] *Web content accessibility guidelines (WCAG) 2.1*. W3C. (n.d.). https://www.w3.org/TR/WCAG21/