CS-25-304 and SON Researchers

Project Proposal

Prepared for

Lana Sargent

VCU School of Nursing

By

William Meredith
Alex Davidkov
Haley Vivian
Edson Decker

Under the supervision of

John Leonard

Date
10/11/2024

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.

Table of Contents

Section A. Problem Statement

The Mobile Health and Wellness Program (MHWP) at VCU serves underrepresented populations in Richmond, collecting extensive data through the RedCap system, including demographics, test results, and surveys. However, researchers face difficulties in efficiently organizing and filtering this data to find participants meeting specific criteria, delaying health studies and hindering research success.

The problem affects MHWP researchers who must sift through large datasets to find participants with specific health attributes or demographics. This issue is common in research programs using large-scale data but lacking efficient tools for participant identification and recruitment. In healthcare research, timely recruitment is critical to the success of studies and interventions. Delays in this process can increase costs, slow research, and miss opportunities to improve health outcomes for the patient.

The project client is the MHWP research team at VCU health, and the primary stakeholders include researchers, clinicians, and the participating communities. These stakeholders rely on accurate, timely data to address critical health disparities and ensure that research efforts are meaningful and actionable. The unmet need is for a solution that will enable researchers to quickly and easily access and filter participant data based on specific criteria, such as test results, demographic information, and health trends.

This project falls under the field of health informatics and research data management. It seeks to advance current technologies by developing a prototype API and an application that can pull data from the RedCap system and allow for more streamlined participant selection. Existing tools, such as basic database querying systems, do not provide the level of customization and specificity required for MHWP researchers. Although past attempts to address similar problems have focused on creating generalized data visualization and search tools, these systems are not tailored to the specific needs of community-based health research programs like MHWP.

This project enhances existing technologies by introducing advanced data filtering and a user-friendly interface tailored to MHWP's needs. It will improve participant recruitment, speed up research, and contribute to better health outcomes for underserved communities. By improving data handling, the project can also serve as a model for other health research programs, advancing the field of healthcare informatics.

In conclusion, this project seeks to address a crucial gap in healthcare research by developing a system that optimizes data retrieval and participant identification. It will build upon existing methods while introducing novel features tailored to the needs of MHWP researchers, ensuring that health studies can proceed efficiently and effectively.

Note: The problem statement should be updated between major reports as more knowledge is acquired and understanding of the project expands.

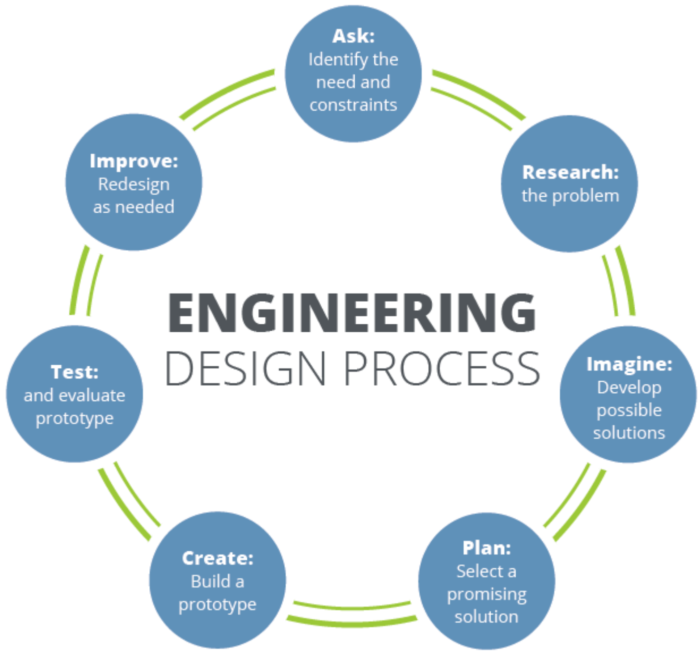

Figure 1. The iterative nature of the engineering design process [2].

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 goal of this project, from the perspective of the MHWP researchers and stakeholders, is to develop a system that improves the process of participant identification and data analysis from large datasets collected through RedCap. Specifically, the system should enhance the ability of researchers to filter, analyze, and retrieve data efficiently, streamlining the recruitment process for health studies.

To produce an improved method for achieving some function

- To create a more efficient method for identifying participants who meet specific research criteria (e.g., demographics, health metrics) based on the data stored in the RedCap system.
- To design a tool that provides researchers with faster, more accurate access to critical data points, improving decision-making in the research process.
- To integrate the system with RedCap while ensuring it works as a website application, supporting both researchers and clinicians in field-based settings.
- To ensure the solution complies with all necessary data privacy and security standards, such as HIPAA, safeguarding participant information.

B.2 Design Objectives

- The design will provide **advanced filtering capabilities** for participant data, allowing researchers to quickly and efficiently identify individuals based on specific criteria such as demographics and health metrics.
- The design will ensure **integration with the RedCap system**, allowing for real-time data retrieval and analysis, and presenting the data in an accessible format for research use.
- The design will ensure **data security and privacy**, adhering to all HIPAA compliance requirements, and protecting sensitive participant information.
- The design will be **user-friendly and intuitive**, allowing non-technical users, such as researchers and clinicians, to easily navigate and use the application in community-based settings.

B.3 Design Specifications and Constraints

The following design specifications and constraints outline the limitations, restrictions, and requirements that must be met for the project to be successful. These specifications are tied to the objectives and ensure the design fulfills its intended purpose. They are measurable, specific, and help assess whether the final design meets all required goals.

Specifications:

1. **Integration with RedCap (Functional Constraint):**

The design must seamlessly integrate with the existing RedCap system to retrieve and manage data without disruption.

2. **Tablet Compatibility (Hardware Constraint):**

The system must be compatible with both Android and iOS, ensuring smooth operation and performance on these platforms.

3. **User Interface Usability (Usability Constraint):**

The interface must be intuitive and user-friendly, allowing non-technical users, such as researchers and clinicians, to easily navigate the system without extensive training.

4. **Data Security and HIPAA Compliance (Legal/Policy Constraint):**

The design must meet HIPAA standards to protect sensitive participant data, ensuring encryption and secure access control.

5. **Performance (Efficiency Constraint):**

The system must efficiently handle large datasets, with retrieval and filtering processes completed in a timely manner, minimizing lag or downtime during usage.

Constraints:

1. **Cost (Cost Constraint):**

The total development cost of the system must not exceed the allocated budget, making efficient use of available resources and leveraging existing infrastructure wherever possible.

2. **Maintainability (Maintainability Constraint):**

The system must operate with minimal maintenance required, and any updates or fixes should be easily implementable without extensive downtime.

3. **Interoperability (Interoperability Constraint):**

The design must ensure compatibility with existing research workflows and tools, utilizing standardized APIs and communication protocols for data exchange.

4. **Data Processing Limitations (Data Constraint):**

The system must be capable of processing and filtering large datasets, adhering to limits on data size and complexity to maintain smooth operation.

B.4 Codes and Standards

List all specific codes and standards that are relevant to the design providing specific details of each as they relate to the design. While the terms codes and standards are often used interchangeably, there are in fact important differences in their definitions that should be understood. **Standards** are documents that provide a set of technical definitions, instructions, rules, guidelines and/or characteristics of a product, process, or service meant to provide consistent and comparable results (e.g. performance requirements, dimensions, testing procedures, file formats etc.). They allow for interchangeability of components and system interoperability and are typically produced by industry or professional organizations such as ASME, ANSI, ASTM, IEEE, ISO, ACM, IAPP, AIS, etc. Standards are meant to help ensure quality, reliability, and safety.

Codes are laws or regulations that specify the methods, materials, components, etc. required for use in a certain product, process, or structure. Codes have been *codified* into a formal written policy or law and can be approved at the local (municipal), state, or federal level. While standards provide sets of guidelines, codes are constraints that *must* be met in accordance with the law. It is, however, common for codes to reference or require the use of one or more standards. Some common code producers include the EPA, OSHA, DOTs, and the NFPA. Codes help set minimum acceptable levels in order to protect public health, safety, welfare.

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)
- Human Research Protection Program/Institutional Review Board (IRB/HRPP): A group that has been formally designated to review and monitor biomedical research involving human subjects in accordance with FDA regulations.
- General Data Protection Regulation (GDPR): A heavy regulation that governs the way in which we can use, process, and store personal data. Introduced by the European Union in 2018.

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.

Note: Relevant codes and standards should be incorporated into the design specifications and constraints listed above.

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.

Our project is based in web development, and our deliverables are mainly online-based, with the exception of in-person presentation of the project. We will mainly be using Discord for communications and file-sharing, and will also use Google Drives and Docs for simultaneous project collaboration. Our project team will also be using GitHub to host our source files and provide status reports of the progress we are making throughout the project. Since our project is all online, we do not need any ordering from third-party vendors or ordering of any physical assets.

- Due Oct 8th: Database Landing Page Compilation Report
- Due Oct. 11th: Fall 2024 **Major Deliverable #2:** Project Proposal
- Due Oct. 18: Initial Figma Design Prototype
- Due Nov. 15th: Fall 2024 **Major Deliverable #3:** Fall Design Poster
- Due Dec. 9th: Fall 2024 **Major Deliverable #4:** Preliminary Design Report
- Due End of Spring Semester 2025: Final Design Report

C.2 Milestones

Milestones are major project phases or tasks that need to be completed in order to ensure the project deliverables. They may include, among other things, completion of calculations, the development of a computational model, completion of an analysis, set-up of an experiment, completion of data acquisition, purchasing of hardware, assembly of a prototype, completion of testing procedures, development of required code, completion of wiring, post processing, etc.

A good rule of thumb is to break the project down into tasks of no larger than 2-3 weeks in length. These can be individual or group tasks. Breaking down the project into tasks/milestones gives the team and the advisor/sponsor a realistic understanding of what can be done in the allotted time. In an agile development approach, later tasks are expected to be adjusted (or changed) as the team works with the earlier developed tasks.

The amount of time it will take to accomplish each milestone and the approximate date that each milestone will be completed should be considered. Do not underestimate the time that it takes to write and prepare major reports and presentation materials. All deliverables and milestones should be included in the project timeline found in Appendix 1. Provide a summary table of all project milestones including required times and completion dates here.

Note: While the project scope, deliverable, and milestones are not intended to change throughout the project, this section should be revisited between major reports to ensure that it still accurately reflects the expectations and requirements of the project team, client, and faculty advisor. Any changes to the project scope, deliverable, and milestones should be thoroughly discussed and mutually agreed upon by all parties. Any changes to this section should be documented and justified in detail.

Milestone 1: Completion of Initial Design Module

- Analyze various features from existing medical and government databases.
- Compile our findings and present various design possibilities to project sponsors/stakeholders for feedback.
- Utilizing stakeholder feedback, generate high quality Figma prototype of database webpage.
- Length of completion: 2 weeks

Milestone 2: Develop Deeper Understanding of REDCap database

- Meet with project sponsors and members of other Capstone teams to gleam insight from the sponsors REDCap presentation.
- Utilize this knowledge to apply to our project design regarding database integration.
- Use preset demonstration modules for REDCap to facilitate individual comprehension of the REDCap web application.
- Length of completion: 3 weeks

Milestone 3: Initial Figma Design Prototype

- Using the compilation report feedback, create an initial rough draft in Figma Jam Board for each of the various pages and attributes of the full site.
- Present draft and use feedback from team members, sponsors, faculty mentor, and stakeholders to iterate design changes and improve design of the application.
- Create a click through prototype using the flow function to test functionality.
- Length of completion: 2 weeks

Milestone 4: Iteration on Initial Design

- Using feedback, create a second draft in Figma Jam Board for each of the various pages and attributes of the full site.
- Edit the click through prototype using the flow function to test functionality.
- Present draft and use feedback from team members, sponsors, faculty mentor, and stakeholders to iterate design changes and improve design of the application.
- Length of completion: 2 weeks

Milestone 5: Iteration on Second Design

- Using feedback, create a third draft in Figma Jam Board for each of the various pages and attributes of the full site.
- Edit the click through prototype using the flow function to test functionality.
- Present draft and use feedback from team members, sponsors, faculty mentor, and stakeholders to iterate design changes and improve design of the application.
- Length of completion: 2 weeks

Milestone 6: Final Prototype Design

- Using feedback, create a final draft in Figma Jam Board for each of the various pages and attributes of the full site.
- Finalize the click through prototype using the flow function to test functionality.
- Present to sponsors, faculty mentor, and stakeholders to finalize design for the application.
- Length of completion: 2 weeks

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.

IDE: VS Code (Live Share function allows for active coding collaboration)

Front-end: Next.js (React-based), Docker, Figma (prototyping), Quarto (prototyping)

Back-end (Database): mySQL, REDCap

Middle-ware: TBD

Host Platform: TBD

Section D. Concept Generation

A number of methods can be used to help generate design concepts from simple reflection and brainstorming, to working the problem backwards, using reverse thinking techniques, and looking to nature for inspiration (i.e. biomimicry). Existing solutions, or components of existing solutions, can be substituted, combined, adapted, modified, put to other uses, eliminated, or rearranged to meet new design objectives and specifications. A minimum of 3 overall design concepts is required for this section although more are welcome. Provide a brief description of how each design concept addresses the design problem. Discuss the potential pros and cons, including and potential risks of failure, of each of these concepts.

It is likely that each design concept may consist of several components. In this case, one or more of these components may offer a sub-problem that can be further explored, modified, or otherwise improved upon. These sub-problems may lead to the addition of several additional design concepts and may require the inclusion of a design concept chart or matrix to organize all ideas and potential solutions.

Provide any initial design sketches, drawings, 3D renderings, or conceptual models such as data flow diagrams, process flows, etc. developed during the concept ideation phase. All hand drawings should be drawn to scale using basic engineering drafting tools (i.e. ruler, protractor, and compass). Geometric stencils can also be used to help produce quality hand drawings. Drawings should be presented in a profession manner, preferably done on engineering graph paper and using a high-quality scan. All sketches should be labeled to identify major components and different drawing views or projections if applicable. Basic dimensions should be provided to give a general sense of scale. Label each sketch or drawing with the name of the team member responsible for the sketch, the date it was drawn, and the drawing scale.

Section E. Concept Evaluation and Selection

Using a systematic decision-making process, evaluate each of the design concepts and choose the one that is most likely to succeed in meeting the design objectives and constraints. A Decision Matrix, or Pugh Matrix, helps to analyze alternatives, eliminate biases, and make rational decisions through thought and structure. First, work to develop a set of selection criteria for which to evaluate the previously generated design concepts. Selection criteria often include concepts of performance, cost, safety, reliability, risk, etc. Note that the selection criteria developed here will likely be more general than the project design objectives. As with the design objectives, conversations with the client help define appropriate selection criteria.

In many cases, the client may value the selection criteria differently, preferring that more emphasis be placed on some than others. In this case, weighting factors may be used to place more or less importance on the various criteria in the decision making process. Again, conversations with the client can be used to define criteria weighting factors. Often times, these conversations must be analyzed and interpreted by the team to determine which criteria are more important to the client and by how much. Feel free to discuss the assigned weighting factors with the client to see if they seem accurate.

Next, define an associated metric to represent each criteria. Metrics should be specific and quantifiable, providing numerical values that quantify the often vague concepts of the selection criteria. Metrics can be obtained, generated, or estimated through a number of methods including simple background research, preliminary design calculations, or basic analyses. Note that these metrics do not need to specifically align with the design specifications although there may be some commonality between the two. Provide a brief discussion of the rationale for selecting each of the assigned metrics.

Using the defined metrics, evaluated each design concept against all selection criteria by filling out a Decision Matrix. Design concepts can be compared by using simple rank scoring, raw scoring, or weighted scoring techniques and design concepts with which to move forward can be selected. This type of process provides a meaningful, unbiased means for choosing a preliminary design concept prior to moving forward with more comprehensive, detailed analyses as provided in the design methodology section below. The results of this process should be discussed with the project client prior to moving forward with the selected design. Table 1 provides an example of a simple decision matrix.

Table 1. Example of a Decision Matrix.

	Design Concept A	Design Concept B	Design Concept C	Design Concept D
Criteria 1				
Criteria 2				
Criteria 3				
Criteria 4				
Criteria 5				
Total Score				

Note: Weights can be assigned to each criterion if desired.

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 specifications, 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 (e.g. FEA or CFD Modeling, example sub-section)

F.2 Experimental Methods (example subsection)

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

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.

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 data flow 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 an appendix.

G.1 Modeling Results (example subsection)

G.2 Experimental Results (example subsection)

G.3 Prototyping and Testing Results (example subsection)

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

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 to 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.

H.1 Public Health, Safety, and Welfare

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 previously provided and the organizations that produced them may be summarized or referenced here.

H.2 Societal Impacts

H.3 Political/Regulatory Impacts

H.4. Economic Impacts

H.5 Environmental Impacts

H.6 Global Impacts

H.7. Ethical Considerations

Section I. Cost Analysis

Provide a simple cost analysis of the project that includes a list of all expenditures related to the project. If an experimental test set-up or prototype was developed, provide a Bill of Materials that includes part numbers, vendor names, unit costs, quantity, total costs, delivery times, dates received, etc. Do not forget to include all manufacturing costs incurred throughout the completion of the project. If the design is expected to become a commercial product, provide a production cost estimate including fixed capital, raw materials, manufacturing (including tooling and/or casting), and labor costs to produce and package the device. Note that this type of detailed cost analysis may be listed as a project deliverable.

Note: The Preliminary Design Report should include all costs incurred to date. It is expected that this section will be expanded and updated between the preliminary and final design reports.

Section J. Conclusions and Recommendations

Use this section to summarize the story of how the design team arrived at the final design. Focus on the evolution of the design through the use of the engineering design process including lessons learned, obstacles overcome, and triumphs of the final design. Revisit the primary project goals and objectives. Provide a brief summary of the final design details and features paramount to the function of the design in meeting these goals and objectives.

A discussion may be included to discuss how the design could be further advanced or improved in the future. If applicable, summarize any questions or curiosities that the final results/design of this effort bring to mind or leave unanswered. If this project might continue on as a future (continuation) senior design project, detail the major milestones that have been completed to date and include any suggested testing plans, relevant machine drawings, electrical schematics, developed computer code, etc. All relevant information should be included in this section such that future researchers could pick up the project and advance the work in as seamless a manner as possible. Documents such as drawings, schematics, and codes could be referenced here and included in one or more appendices. If digital files are critical for future work, they should be saved on a thumb drive, external hard drive, cloud, etc. and left in the hands of the project advisor and/or client.

Appendix 1: Project Timeline

Provide a Gantt chart of similarly composed visual timeline showing the start and end dates of all completed tasks and how they are grouped together, overlapped, and linked together. Include all senior design requirements including design reports and Expo materials (i.e. Abstract, Poster, and Presentation). All major milestones should be included in the 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.

Appendix 3: [Insert Appendix Title]

Note that additional appendices may be added as needed. Appendices are used for supplementary material considered or used in the design process but not necessary for understanding the fundamental design or results. Lengthy mathematical derivations, ancillary results (e.g. data sets, plots), and detailed mechanical drawings are examples of items that might be placed in an appendix. Multiple appendices may be used to delineate topics and can be labeled using letters or numbers. Each appendix should start on a new page. Reference each appendix and the information it contains in the main text of the report where appropriate.

Note: Delete this page if no additional appendices are included.

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] VCU Writing Center. (2021, September 8). *APA Citation: A guide to formatting in APA style.* Retrieved September 2, 2024. https://writing.vcu.edu/student-resources/apa-citations/

[2] Teach Engineering. *Engineering Design Process*. TeachEngineering.org. Retrieved September 2, 2024. https://www.teachengineering.org/populartopics/designprocess