VCU College of Engineering

CS 25-307 AGIE follow-on

[Preliminary Design Report]

Prepared for

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Executive Summary

Women remain significantly underrepresented in STEMM (Science, Technology, Engineering, Mathematics, and Medicine) fields, particularly in faculty and leadership roles in higher education. Addressing this disparity, our project focuses on creating a centralized, user-friendly repository for higher education administrators to access targeted resources and strategies for promoting gender equity. This initiative not only streamlines the process of finding relevant information but also empowers administrators to implement evidence-based solutions effectively.

Currently, administrators face a fragmented and inefficient process of manually searching for gender equity resources, hindering progress. Our proposed solution consolidates this information into a dynamic, easily navigable platform designed specifically to meet their needs. The repository will feature advanced search and filtering capabilities, administrative control tools, and seamless deployment using cutting-edge technologies like Docker and GPT-powered features.

The project goals are defined by clear objectives:

1. Enhancing Usability and Navigation – Ensuring users find desired resources within three clicks, supported by intuitive design and fast load times.
2. Facilitating Administrative Control – Offering a streamlined dashboard for content management and resource tracking to simplify updates and analysis.
3. Ensuring Scalability and Compatibility – Leveraging Docker for rapid deployment and ensuring cross-platform functionality on major operating systems.

Our design adheres to industry standards, including W3C guidelines, ISO usability principles, and legal requirements like data protection regulations. With measurable targets and time-bound deliverables, we aim to deliver a robust solution that fosters actionable change in STEMM equity initiatives.

By addressing systemic inefficiencies and providing a tailored solution, this project supports higher education institutions in advancing gender equity in STEMM fields—an essential step toward a more inclusive academic landscape.

Section A. Problem Statement

Before a design solution is proposed, it is first important to identify, define, and fully understand the problem. Through a significant research effort, provide all relevant background information needed to understand the reasons for doing the project and the **unmet engineering need(s)** being addressed by the project. Assume that the reader does not have existing knowledge of the problem. Some questions that may be addressed by the problem statement include who is facing the problem and why? How widespread (i.e. common) is the problem? How often does the problem occur? What are the potential costs associated with the problem (e.g. economic, environmental, societal, health and safety, etc.)? Who is the project client? Who are the stakeholders? The problem statement should be narrative in nature. It should provide a framework for the project and clearly convey the primary goal(s) of the project.

Discuss the general field of study or industry that the project falls under and how the project contributes to, or advances the current technology in that field. For industry sponsored projects, a brief introduction of the sponsor company and relevant product line(s) is appropriate. For faculty sponsored projects, a description of the laboratory and type of work performed in the lab is appropriate. Put the current project into historical perspective using external references. Determine if the problem, or a closely related problem, has previously been addressed. If so, summarize the results, including any relevant data and/or conclusions, and discuss how this project improves or builds on previous results. For industrial projects, see what non-sensitive information about the process or product line your sponsor will provide. Look for commercially available competitive designs, relevant patents, and alternative design options. For academic studies, search for published journal articles in the field of study. See what papers have been published leading up to the current project. Looking at an article's references may provide additional lines of references. What are the pros and cons of each prior solution attempt?

Figures can often help aid in the discussion and understanding of technical subject matter. Examples of figures may include a labeled, detailed mechanical drawing, 3D rendering, photograph, schematic, process flow chart, etc. All figures should include a figure number and title located below each figure, and a reference number if necessary. The introduction should include a minimum of 5 cited references. More are encouraged. All references should be cited in-text and on a reference page at the end of the report using the APA citation format [1]. Figure 1, illustrating the engineering design process, provides an example of a properly labeled and cited imaged. Given the level of investigative detail required for this design report, it is expected that the introduction will consist of several pages.

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

- Women are very underrepresented in STEMM fields, and the main goal of the project is to create a central repository to provide information on promoting gender equity in faculty and leadership positions in higher education. Currently, administrators must manually search for strategies, which is time-consuming and inefficient. The repository will streamline this process, making it easier for administrators to find relevant studies and strategies tailored to their institutions.

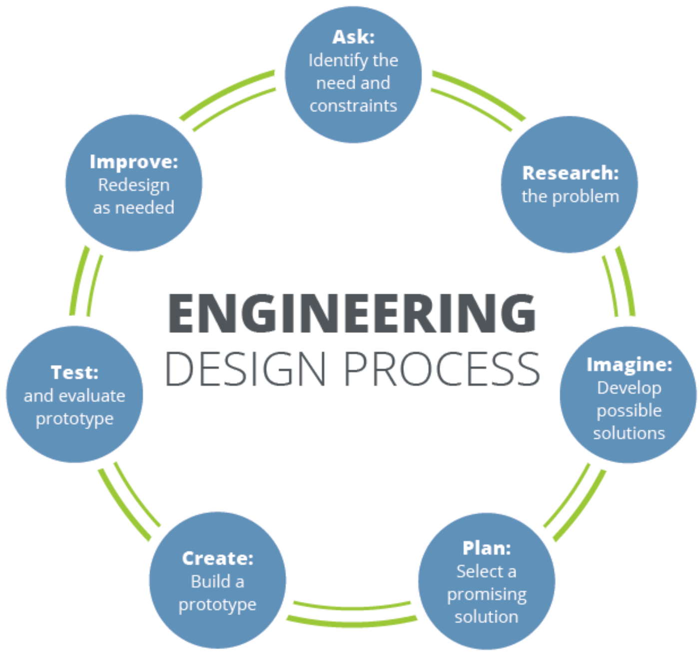


Figure 1. The iterative nature of the engineering design process [2].

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)

Describe the overall goals of the project from the point of view of the customer or client. Goals should be derived from the specified needs of the project and *do not explicitly describe what the design will do*. They should be short, concise, and achievable. Bulleted lists are a good way to present key points and draw the reader's attention to those points. Note that a few sentences should be included at the beginning of any section using a bulleted list to introduce the content of the section and lead into the upcoming list. Some general examples of project goals are as follows:

- To produce an improved method for achieving some function
- To design a smaller, cheaper, faster, etc. device that performs some function
- To perform an experiment to produce data to gain a better understanding of some phenomena
- To produce a model that more accurately predicts some physical behavior

- The central goal is to build a user-friendly and easily navigable repository that serves higher education administrators. The repository should facilitate the search for publications and resources on improving gender equity in STEMM fields.

Client Needs:

- Create a centralized hub for administrators.
- Ensure it is easy to navigate and dynamic for ongoing management.
- Must support filtering information and allow administrative/curator access.
- Redesign the web site based on lessons learned from last year's project, and extend implementation technologies to include a built-in GPT and deployment using docker-compose and docker.

B.2 Design Objectives

List the key objectives of the design that you will produce. Objectives describe *what the design will do*, not how it should do it. Objectives should be SMART – Specific, Measurable, Achievable, Realistic, and Time-bound. Each objective will ultimately be linked to a design specification/constrain during the design process. Again, lists are nice if applicable.

- The design will…be specific.
- The design will…make sure the objective has the ability to be measured.
- The design will…make sure the objective is achievable given your resources.
- The design will…make sure the objective is realistic.
- The design will…make sure you have a reasonable time to achieve the objective.

1. **Enhance Usability and Navigation**
    - **Specific**: The website should allow users to easily browse and search for gender equity resources in STEMM fields.
    - **Measurable**: Achieve a target of users finding their desired resources within 3 clicks or less.
    - **Achievable**: Implement a clear, modular layout with intuitive filters and a well-structured navigation system.
    - **Realistic**: Utilize proven UX design techniques to create a logical, user-friendly interface.
    - **Time-bound**: Complete the development of the navigation system within
2. **Support Administrative Control and Resource Management**
    - **Specific**: Enable administrative/curator access for managing content updates and tracking resource usage.
    - **Measurable**: Admins should be able to upload, tag, and organize content in less than 5 minutes per entry

- **Achievable**: Provide a straightforward content management dashboard.
- **Realistic**: Ensure the dashboard can handle ongoing content uploads and updates without downtime.
- **Time-bound**: Complete the admin panel functionality within

3. **Ensure Cross-platform Deployment with Docker**

- **Specific**: Deploy the repository using Docker and Docker-Compose for cross-platform compatibility and easy scalability.
- **Measurable**: Ensure 100% functionality across different operating systems.
- **Achievable**: Use well-documented Docker deployment strategies for web apps.
- **Realistic**: Collaborate with DevOps to ensure smooth deployment across various environments.
- **Time-bound**: Deploy the first fully functional version of the website within

B.3 Design Specifications and Constraints

A list of design specifications and constraints include all limitations, restrictions, and requirements of the design. They are firm limits that must be met for a design to be acceptable and are ultimately used to measure the success of a design. Each specification or constraint should map to one or more design objective(s) and explicitly state *how the design* will meet the objectives. Specifications and constraints should be specific and are often numerical. They must be measurable or testable to prove that the design has met all of the design objectives. Numerical metrics may include qualifying statements such as "at least," "at most," "between," "exactly" or include a set of discrete values. Avoid subjective, untestable constraints (e.g. "environmentally friendly", "user friendly", "nice looking", etc.).

Realistic constraints can come take on a variety of forms including accessibility, aesthetics, codes, constructability, cost, ergonomics, extensibility, functionality, interoperability, legal considerations, maintainability, manufacturability, marketability, policy, regulations, schedule, standards, sustainability, or usability. Examples of physical constraints might include numerical limits or ranges on overall size envelope, weight, pressures, stresses, flow rates, voltages, current, power consumption, hardware limitations, data constrains, interoperability, etc. Other constraints might include production unit cost, expected part/device life, or maintenance requirements.

Some general examples of constraints are as follows:

- Design must integrate with existing equipment or process (Functional constraint) – examples include specific piping or electrical connections, available size envelope, power requirements, etc.
- Design must not exceed some overall weight (Functional constraint) – specify weight limits or range

- Design must not exceed some power consumption or operate at some efficiency (Functional constraint) – examples include current, voltage, power requirements, mechanical or electrical efficiency
- Must be cheaper to produce than currently available designs (Cost constraint) – provide specific cost limit or range
- Design must be made from readily available materials (Manufacturability constraint) – provide exact materials
- Design must operate for so many hours without requiring maintenance (Maintainability constraint) – provide exact time or range
- Design must operate within some hardware with specifications up to certain values (Hardware constraint) – provide exact hardware specifications
- Design must operate within some constrains on data collection and processing (Data Constrains) – provide exact guidelines or restrictions
- Design must operate within a set of systems or platforms requiring compatibility with specific protocols or APIs (Interoperability Constrains) – provide specific systems of platforms.

1. Usability and Navigation

- **Specification**: Users must find desired resources within 3 clicks or less.
  - **Objective**: Enhance usability and navigation.
  - **Constraint**: Interface should maintain a maximum of 3 hierarchical layers for resource discovery (e.g., category → subcategory → content).
  - **Measurable Metric**: At least 90% of user tests should confirm that users can reach content within the 3-click limit.
- **Specification**: Load times for pages and resources must not exceed 5 seconds.
  - **Objective**: Improve user experience with efficient navigation.
  - **Constraint**: Page load speed should be optimized using lightweight front-end assets and server-side caching.
  - **Measurable Metric**: Measured page load time must stay under 5 seconds on standard network speeds.

2. Cross-platform Compatibility

- **Specification**: The website must function correctly on at least 90% of major platforms (Windows, MacOS, Linux).
  - **Objective**: Ensure cross-platform deployment using Docker.
  - **Constraint**: The system should be deployable using Docker-Compose on various environments without compatibility issues.
  - **Measurable Metric**: Successful cross-platform functionality in 9 out of 10 environments during testing.
- **Specification**: The entire website should be deployable in less than 5 minutes via Docker.
  - **Objective**: Ensure rapid deployment and scalability.
  - **Constraint**: Docker-Compose configuration should support quick builds and deployments.
  - **Measurable Metric**: Deployment testing should confirm successful deployment in under 5 minutes.

3. Data and Privacy Constraints

- **Specification**: The system must comply with relevant data protection regulations.
  - **Objective**: Ensure legal compliance in user data management.
  - **Constraint**: Personal data must be encrypted, and user consent should be explicitly obtained before data processing.

Measurable Metric: Compliance audits and legal verification

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.

Codes and standards are often listed by their producer followed by an identifying numerical code. They often contain hyphens or periods which may help reference specific parts of a larger code/standard or provide the year of the latest revision. Some general examples in a list of codes and standards are as follows:

- ASME Standard No. xxx – design must consider some specific fatigue failure criteria
- IEEE Standard No. xxx – design components must not exceed some maximum current limit
- ISO Standard No. xxx – design components must adhere to some standard thread size
- OSHA Code No. xxx – operators of design must wear appropriate eye and face protection
- IRTF Standard No. xxx – design must consider internet communication protocols
- W3C Standard No. xxx – design must adhere to some HTML/CSS standards
- NIST Standard No. xxx – design must consider some specific data security standards

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

1. Web Development Standards

- **W3C HTML Standard 5.3** – The website must adhere to the latest **HTML5** standards to ensure compatibility across all browsers.
    - **Relevance**: Ensures proper structure, presentation, and behavior of web pages across different platforms.

2. Legal and Regulatory Codes

- **OSHA 1910.132** – Code for providing user safety protections, especially in systems accessed in educational institutions.
    - **Relevance**: Ensures that, should the website have physical hardware or interactive kiosks, proper safety measures are in place.

3. Docker and Containerization Standards

- **OCI (Open Container Initiative) –** Container format standard.
    - Relevance: Ensures that Docker containers used to deploy the website repository follow best practices and industry standards, making the system portable, scalable, and secure.

4. **Usability and User-Centered Design Standards**

- **ISO 9241-210:2019** – Human-Centered Design for interactive systems.
    - **Relevance**: Ensures that the website follows user-centered design principles, leading to better usability, accessibility, and overall user satisfaction

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?

Major Fall Deliverables

Team Contract due Sep 6	A team contract document is required early in the semester prior to the project proposal. The purpose of this document is to become well acquainted with all active members of the project (e.g. student team members, faculty advisors, industrial sponsors, etc.). The contract includes listing individual student team member strengths, roles, and responsibilities. It also lays out the time commitments, means of communication, and meeting structure for everyone invested in the successful completion of the project as listed above. Completion of this document requires early, open commination between all of these parties. Important: CS Students are also required to set up the project repository in CS GitHub with all team members registered.
Project Proposal due Oct 11	The project proposal serves as a means to frame the project early on in the design project. It includes a brief introduction (i.e. background, literature review) section that provides relevant background information on the project including the reasons for doing the project and the unmet engineering need(s) addressed by the project. A comprehensive project definition section defines the goals, objectives, and constraints of the project. A project scope, which helps define the boundaries of the project, and complete list of expected deliverables are also included. Finally, an organizational structure and proposed timeline are provided.
Fall Design Poster due Nov 15	A design project poster will be required at the end of the semester. The poster should highlight the preliminary results of the design and include a brief project background, design criteria, and analysis methods. A live poster session will be scheduled for the end of the semester where students will present their results to the public which may include sponsors, faculty, administrators, and other students. The poster will be similar in nature and design to the Capstone EXPO poster due at the end of the spring semester and presented at the culminating Expo event (more details below).

Preliminary Design Report Due December 9	Each student team must submit an end-of-semester preliminary design report efforts throughout the semester. This report should provide more detailed background than provided in the proposal and an updated project definition (i.e. design criteria) section. This report should clearly and methodically layout the design process completed by the student team to date. Additional required sections include ‘Concept Generation’, ‘Design Methodology’, ‘Concept Selection’, and ‘Additional Design Considerations’. Any preliminary results that have been obtained by the end of the semester should also be presented in detail in this report. A preliminary cost analysis and review/update of the project timeline is also required.

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.

- Review landing pages and create a Presentation to discuss (going over some designs and implementations in these landing pages, see what they like and don't like. Also get a better picture of who will be using the site) - by 10/25/24
- **Complete Fall Poster-** As a team create our fall poster after we meet with the AGIE team, this process should take us about 1 week to complete.
- **Develop a functional prototype-** Should take about 2-3 weeks to come up with a working draft. Longer depending on the difficulty to incorporate the backend into the UI
- **Complete Preliminary Design Report-** Do proper research and add a detailed background that addresses concepts that were not explained thoroughly on the project proposal. A detailed project design process should be included by December 9th.

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.

Github, Github Pages to host the website, Docker & Docker Compose, cloud or on-premise servers for deployment, development, and testing environments.

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 dataflow 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.

1. Modular Layout with Dynamic Filters

- **Description**: This design features a modular layout where content is broken down into intuitive sections, each with dynamic filters that allow users to customize their search based on specific parameters such as publication date, resource type, or category of gender equity initiatives. It would include a quick access menu for frequently used resources and allow real-time content updates by administrators.

- **Pros**:
  - Provides a highly customizable user experience.
  - Modular design allows easy updates and content management.
  - Improves search efficiency through detailed filters.
- **Cons**:
  - Complexity of filters may overwhelm first-time users.
  - Risk of filter bugs that could reduce user accessibility.
- **Potential Risks**: Over-customization can make the repository cluttered, and if the filters are not well-maintained, users might have trouble finding information.

2. Biomimicry-inspired Navigation with Guided Search

- **Description**: Inspired by natural systems, this design adopts biomimicry principles to create a self-organizing navigation system. Information is grouped like a branching tree, guiding users through different layers of resources. Administrators could highlight "featured branches" for prioritized resources, while users can access broader categories or specific, narrow topics based on need.
- **Pros**:
  - Natural and intuitive navigation model.
  - Simple for new users, as they are guided progressively through the repository.
  - Emphasizes discovery and exploration for less frequent users.
- **Cons**:
  - May not be suitable for power users who prefer direct searches.
  - Could make deep resources harder to find without proper labeling.
- **Potential Risks**: The branching structure might lead to "deep scrolling," where users get lost in subcategories, requiring careful curation of content to prevent confusion.

3. Reverse-Engineered AI-Enhanced Search with GPT Integration

- **Description**: This concept involves leveraging reverse engineering techniques to create a streamlined search powered by GPT. Users input vague search queries, and the system refines and enhances the query using GPT to match relevant results. It also includes interactive guidance for administrators to optimize content for searchability.
- **Pros**:
  - Enhances user engagement by providing smart, AI-driven results.
  - Reduces the need for detailed search knowledge or experience.
  - Allows administrators to leverage AI tools for continuous improvement of content presentation.
- **Cons**:
  - Dependence on AI could reduce transparency if users do not understand how results are generated.
  - Increased complexity in implementation and potential troubleshooting issues.
- **Potential Risks**: Over-reliance on AI could introduce biases or irrelevant results, and the GPT integration may require regular tuning and updates to ensure accuracy.

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 concept 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.

Criteria	**Weight**	**Modular Layout with Dynamic Filters**	**Biomimicry-inspired Navigation**	**AI-Enhanced Search with GPT**
Customizability	0.3	9 (2.7)	6 (1.8)	7 (2.1)
Ease of Use	0.2	6 (1.2)	8 (1.6)	6 (1.2)
Search Efficiency	0.2	8 (1.6)	7 (1.4)	9 (1.8)
Implementation Complexity	0.2	7 (1.4)	6 (1.2)	5 (1.0)
Risk of Overwhelming Users	0.1	4 (0.4)	7 (0.7)	6 (0.6)
Total		**7.3**	**6.7**	**6.7**

The decision matrix evaluates three design concepts for the project: Modular Layout with Dynamic Filters, Biomimicry-inspired Navigation, and AI-Enhanced Search with GPT. Each option is assessed against key criteria, including customizability, ease of use, search efficiency, implementation complexity, and the risk of overwhelming users. Based on the weighted scores, the Modular Layout with Dynamic Filters emerges as the top choice, excelling in customizability and search efficiency, though it carries a slight risk of being overwhelming for first-time users.

The other two options, Biomimicry-inspired Navigation and AI-Enhanced Search with GPT, perform well in ease of use and innovation but score lower due to potential risks and higher implementation complexity.

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

Front-End and UI/UX Testing:

- **Tool**: Figma for prototyping and user interaction flow.
- **Method**: A wireframe will be developed to simulate user interactions. The navigation paths and layout will be evaluated for efficiency using user heatmaps and click tracking.
- **Objective**: To ensure the final layout is intuitive.

Back-End Performance Testing:

- **Tool**: Apache JMeter for simulating load and measuring system performance
- **Method**: Simulate Multiple concurrent users accessing various API endpoints. Measure response times, throughput, and resources utilization under different load conditions
- **Objective**: Ensure the system can handle high traffic and maintain performance within acceptable thresholds without crashing or slowing down significantly

F.2 Experimental Methods (example subsection)

- **Search Functionality Testing**:
  - **Method**: Simulate common search queries using a range of inputs.
  - **Equipment**: Automated test scripts for search queries.
  - **Procedure**: Test a series of keyword searches to ensure that the most relevant publications appear within the first 3 results.
  - **Objective**: Achieve intended search results.

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

- **Front-End:**
  - **Framework: React.js for building an interactive user interface.**
  - **Objective: Create a responsive, dynamic interface that allows real-time filtering of resources without page reloads.**
- **Back-End:**
  - **Framework: Node.js will be used to handle database queries.**
  - **Objective: Support efficient API-based communication between the front-end and the back-end, ensuring smooth user experiences.**
- **Database:**
  - **Architecture: A relational database (PostgreSQL or MySQL) with well-structured tables for resources, categories, and filters.**
  - **Objective: Allow quick retrieval of filtered and sorted results based on user queries.**
- **Deployment:**
  - **Method: The system will be containerized and deployed using Docker-Compose for easy scalability and maintenance.**
  - **Objective: Enable fast deployment across different environments with minimal configuration.**

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.

- **Prototyping: Our team will develop a prototype of the website repository by {date}**
- **Testing and feedback: The design will be tested both internally by our team and externally by the client**
- **Iteration and Client Feedback: Feedback that is collected during the validation meeting will be used to finalize the design**

Section G. Results and Design Details

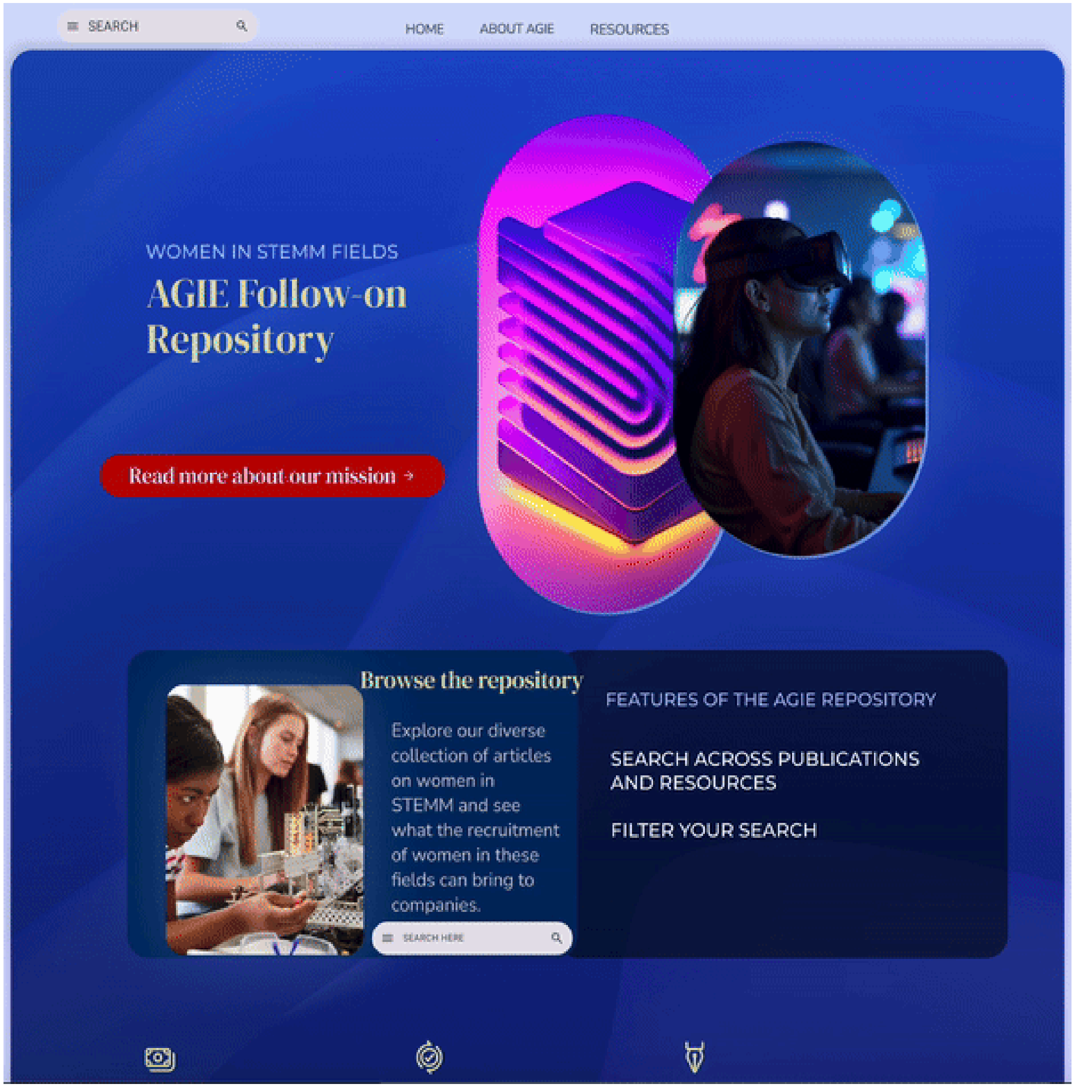
Use this section to highlight the major results of the design methodology described above including important analytical, computational, experimental, modeling, assembly, and testing results. This section should be one of the most substantial sections of the report showcasing all of the hard work and 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.

Experimental and prototyping results:

Prototype #1:


SEARCH
HOME
ABOUT AGIE
RESOURCES
WOMEN IN STEMM FIELDS
AGIE Follow-on Repository
Read more about our mission →
Browse the repository
Explore our diverse collection of articles on women in STEMM and see what the recruitment of women in these fields can bring to companies.
SEARCH HERE
FEATURES OF THE AGIE REPOSITORY
SEARCH ACROSS PUBLICATIONS AND RESOURCES
FILTER YOUR SEARCH

Prototype #2:

Home

AGIE Follow-on Repository

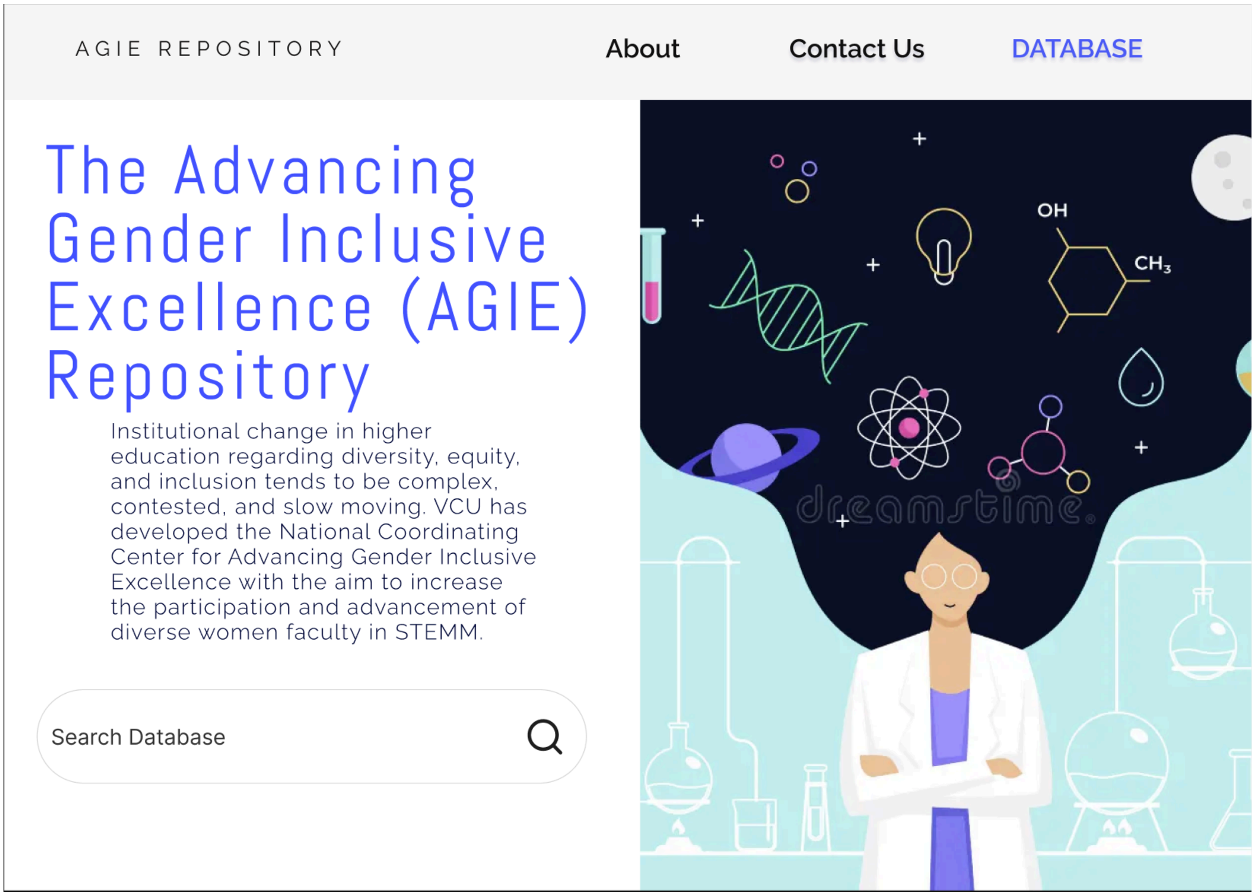
Explore our diverse collection of articles on women in STEMM and see what the recruitment of women in these fields can bring to companies.

Hinted search text

100+

Articles and Publications on women in STEMM

Prototype #3:


AGIE REPOSITORY
About
Contact Us
DATABASE
The Advancing Gender Inclusive Excellence (AGIE) Repository
Institutional change in higher education regarding diversity, equity, and inclusion tends to be complex, contested, and slow moving. VCU has developed the National Coordinating Center for Advancing Gender Inclusive Excellence with the aim to increase the participation and advancement of diverse women faculty in STEMM.
Search Database
OH
CH3
dreamstime

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

1. Accessible Design(W3C WCAG 2.1)

- **Description**: Ensures compliance with ADA (Americans with Disabilities Act) and other relevant accessibility standards to make the site usable for individuals with disabilities.

- **Potential Effects**: Promotes inclusivity, ensuring that individuals with physical or cognitive impairments can easily access and navigate the site, improving their quality of life.

2. **Backup and Recovery(ISO/IEC 27031)**

- **Description:** Provides automatic data backup to prevent data loss in the event of system failures and/or cyberattacks.
- **Potential Effects:** Protects public welfare and ensures the continuity of service and availability of critical resources for higher education administrators or anyone using the repository.

H.2 Societal Impacts

The repository is designed to facilitate the dissemination of research and resources that support gender equality in STEMM fields, which could contribute to societal shifts toward greater inclusivity in education and professional environments. By improving access to information, it encourages a more equitable distribution of opportunities and resources across genders, which can lead to better representation in these fields over time.

H.3 Political/Regulatory Impacts

The site must comply with local and international data protection regulations (e.g., GDPR, HIPAA if applicable) and intellectual property laws. There could be regulatory requirements regarding the distribution of academic publications. These rules will ensure ethical use of resources and compliance with legal mandates, thus potentially influencing policy around education, equity, and information access in STEMM fields.

H.4. Economic Impacts

By providing open access to valuable resources on gender equity in STEMM, the repository may reduce the costs of obtaining such information for educational institutions, government agencies, and researchers. This could promote economic equity, as institutions with fewer resources will have access to the same materials as well-funded organizations. Long-term economic benefits could include increased workforce diversity in high-demand STEMM fields, contributing to broader economic growth.

H.5 Environmental Impacts

The environmental impacts of the website are primarily related to its energy consumption and carbon footprint, which can be mitigated through the use of energy-efficient hosting solutions, such as green data centers or cloud services powered by renewable energy. As an online platform, it reduces the need for physical materials (e.g., print publications), thus contributing to reduced paper use and waste.

H.6 Global Impacts

The repository has the potential to impact gender equity in STEMM fields, as the digital format allows users from different regions to access the materials. It supports international collaboration by providing a centralized platform for best practices and research, thereby fostering cross-border initiatives to improve diversity and inclusion in STEMM.

H.7. Ethical Considerations

The repository must respect intellectual property rights by ensuring that only authorized or licensed content is available. Transparency in the design, data use policies, and moderation processes also plays a key ethical role, helping to maintain trust and accountability in the platform's use.

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.

Materials are not needed for our project as discussed with our faculty advisor, Dr. Leonard.

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 appendix. 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.