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Design Portfolio

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1.0 Introduction

1.1 Purpose

This document outlines my engineering philosophy, consisting of principles and methodologies shaped by my personal experiences and professional endeavors.

This philosophy serves as my guide for approaching complex problems, emphasizing the integration of technical proficiency with a strong social consciousness. It is my firm conviction that the primary objective of an engineer is to create a positive social impact, with the methods to achieve this being secondary. Essentially, the goal is to develop solutions that mitigate the overall "negativities" faced by any "entity". Entities are defined as the environment, groups of people, individuals, species of plants and animals, or even future generations from the longtermism [1, 2] perspective. Negativities refer to situations that result in non-ideal outcomes; in the context of human experience, this could mean reducing cumulative hours of human suffering, which can be alleviated through engineering solutions.

1.2 For me, the Author

For me, this document shall serve as a central pillar to my future engineering design work and shall be a “living document” where I will update my views and perspective accordingly as I mature from a Student Engineer to an Engineer. It shall also provide documentation on tools that were conducive to acceptable solutions, as well as tools that did not work and might work if applied differently.

1.3 For you, the Reader

For you, this document shall provide a description of my previous engineering experience and will also offer insight into my way of thinking, as well as the tools that I have found to be effective (both in a personal and group format), and the type of thinking required (in my opinion) for successful engineering design at the individual and group level.

2.0 Position in Context

2.1 Background and Motivation

My engineering philosophy is firmly grounded in my personal experiences and cultural background. I was fortunate to live in the Middle East for much of life and had a chance at a proper education, however whilst visiting my country was always refreshing, in the periphery there was always a sense of desolation that I felt with the amount of destitution that my fellow countrymen felt. Observing the widespread suffering among my fellow countrymen from a young age has instilled in me a strong commitment to effecting positive change. This motivation has guided my pursuit of engineering, a field I believe has the greatest potential for making a meaningful and positive impact on any given entity.

Engineering has the potential to create significant social impact in the world. When we observe our history as a species, we can see that moments of great suffering (the invention of napalm) [3, 4] and reductions in suffering (the invention of the MRI) [5] were often brought about by engineering solutions. If harnessed correctly, engineering can lead to meaningful positive change in the world.

2.2 Engineering Design Philosophy

This foundational principle guides my approach to engineering design: every solution must be evaluated through the lens of its potential impact on people, other species, and the environment. For me, engineering design is fundamentally a process of identifying problems affecting a group of people or species and developing targeted solutions.

I believe that for any given problem, there exists a theoretically perfect or "true" solution—one in which every aspect has been optimized to eliminate all negative consequences. While this ideal solution remains unattainable within the perspective of a human lifespan, I strive to approach it as closely as possible through rigorous methodology and continuous refinement.

2.3 Key Design Principles

2.3.1 Framing

From my experience with personal projects and Praxis II, I have realized that there are two types of design: high-level design, where we outline the solution; and low-level design, where we detail the actual design elements such as PCBs, CAD, firmware, etc.

2.3.1.1 Form (Purpose) over Function (Technical Implementation)

Regarding high-level design, it is essential to focus on the intended purpose of the design rather than the specific methods employed to implement a particular set of solutions.

In defining "form," I refer to the precise method by which a given solution achieves a desired outcome. In contrast, "function" pertains to the process through which the specific form is realized using tools such as CAD, PCB design, and other related technologies.

For example, during the Christmas break of 2024, when developing a voxel engine (a 3D graphics engine that renders objects made of cubic elements, similar to what powers games like Minecraft), I initially felt overwhelmed by the prospect of writing over 20,000 lines of C++ code. The project seemed impossibly complex when I thought about how to implement the difficult mathematics and vector calculus required, until I broke it down into five distinct sub-problems: multiplayer connectivity, player movement mechanics, procedural world generation, world modification systems, and the rendering pipeline. By taking these high-level features and then slowly refining further down by way of stepwise refinement (a computer science term [6], mostly closely modelled by FSD in praxis [7]). By understanding the form of the problem first, I could approach each component individually with specific solutions rather than attempting to tackle the entire system at once.

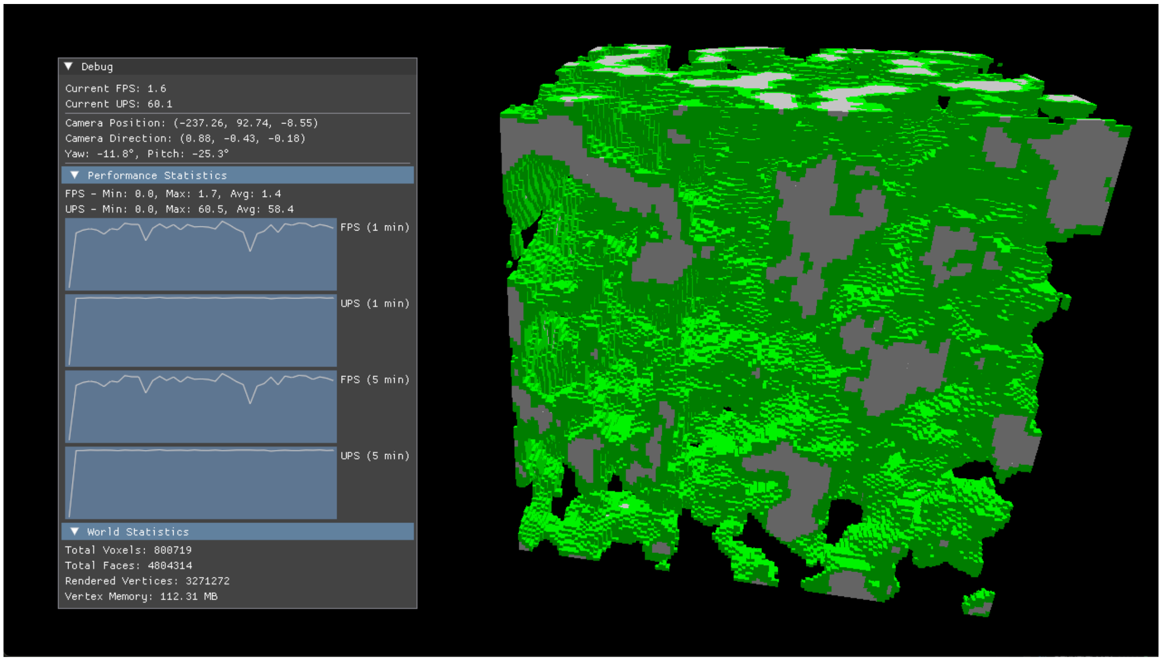


Figure 1: This is the Voxceleron voxel game engine, this engine was used to lay the foundation for Voxceleron2 and involved the layout of the high-level design and had very minimal technical integration to ensure that I had scoped out the entire project before pursuing it to make sure there were not any new things that I had to completely overhaul my knowledge of. Voxceleron2 was the complete implementation of this engine, please see figure 1.

Figure 2: Voxceleron2 voxel game engine, this engine is a completely overhauled version of the game engine and includes an updated rendering pipeline, mesh-generation optimization and has a more complete world-generation algorithm.

2.3.1.2 Systems Thinking

After an initial form has been identified and the features and features of this given form are identified it is important to work on the low-level design and ensure that one implements the features as required by using technology, meaning we do the CAD, the PCB design, run the calculations, etc.

While working on a solar-powered aircraft research project, I observed how changing a single parameter—such as the weight of a component or the efficiency of a solar cell—would create ripple effects throughout the entire system, affecting flight time, structural integrity, and power management. This experience highlighted the interconnected nature of engineering systems and the importance of considering how modifications to one element influence the whole. Shown in figure 3 is the overall way through which the system was simulated and how the change of a single variable had reverberating effects on the design.

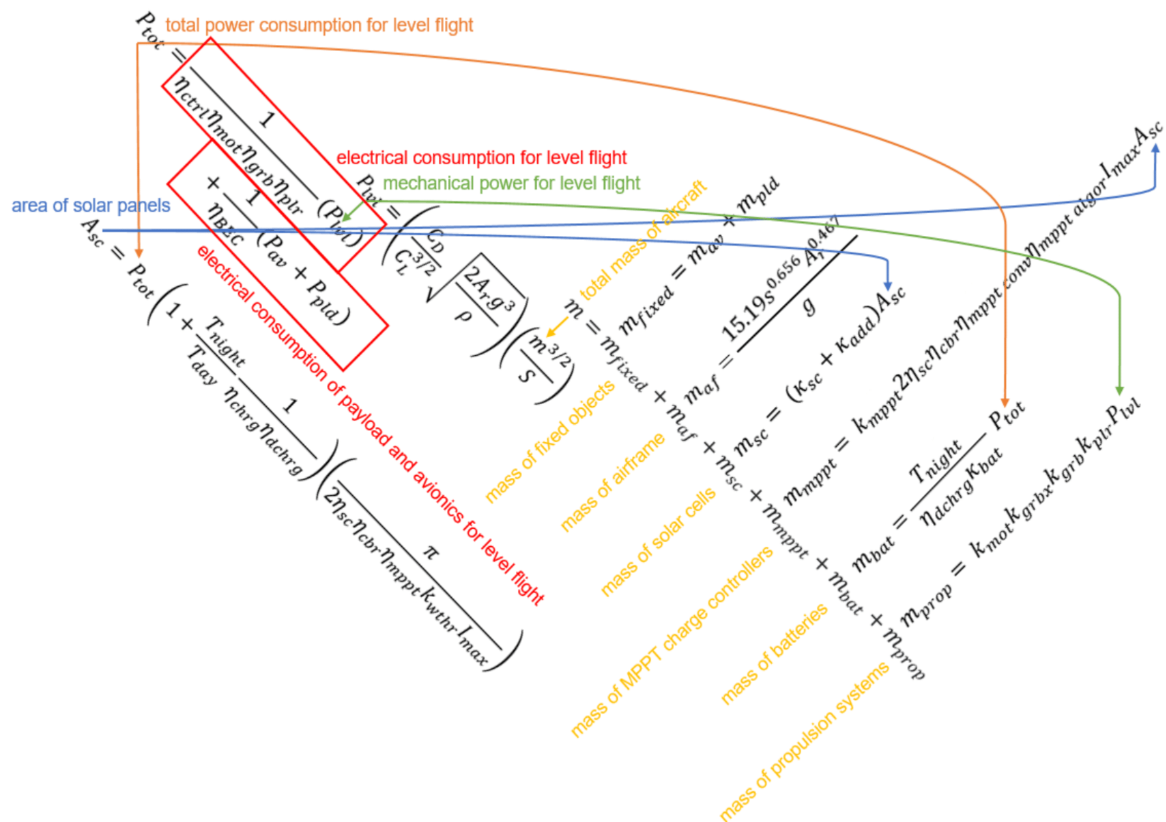


Figure 3: Gives the overall equation for mathematically optimizing all aspects of the solar-power aircraft, it does this by balancing power to mass for all components and then determines whether the final aircraft's parameters are within the real of reality, meaning that there are no parameters where the solar panel area exceeds the total wing area, etc.

I believe that the two considerations mentioned above were further developed in Praxis II, where I recognized a phenomenon in which complexity is often truncated from a given problem to reach a solution. For instance, stating that "...we can use computer vision to detect the chess pieces on a board and then utilize that data…" may sound straightforward, but it oversimplifies the reality. This truncation of detail can lead us to pursue solutions that appear easier than they truly are, ultimately reducing the overall value that the solution provides to a community and hindering its potential for meaningful positive social impact, which is contrary to my primary directive.

To combat this, it is important to have a keen awareness of the issue of this behavior and to remain vigilant by way of educating oneself of the actual implementation of technology we are not familiar with. Moreover, it is also important to ensure that at some stage of the iteration process we implement the low-level design by way of actually doing the PCB design, the CAD, running the calculations, etc. as a sort of "sanity check" to ensure that we are not "barking up the wrong tree".

This two-step process, I've observed, also has the added benefit of allowing non-technical people to contribute meaningfully without needing to know the actual low-level implementation of any given design. This is incredibly important later (given in section 1.3.3.1) as inspiration can come from the most unexpected places and can result in some truly innovative solutions. This also ensures that the community we are "prescribing" a solution to is able to and is empowered to take part in this process of improving their condition thereby reducing their suffering.

2.3.2 Converging and Diverging

With the above discussion in mind, comes the question of how to actually do the exact design process after a set of high-level design features or objectives has been identified. Through my experience I find that the two following principles are essential to a successful design to be created.

2.3.2.1 Iteration is Essential

A few years ago, I undertook a personal project to design a low-cost cantilever 3D printer capable of high-speed, high accuracy printing comparable to commercial models available at the time. During the initial design phase, I spent considerable time working in CAD software, designing each component in detail, however, when I began physical assembly, I encountered numerous unforeseen issues—bolts that couldn't be accessed due to obstructing sub-assemblies and parts that didn't align as expected. This experience taught me that, had I built and tested individual sections as prototypes earlier in the process, these problems would have been identified much sooner, saving time and resources.

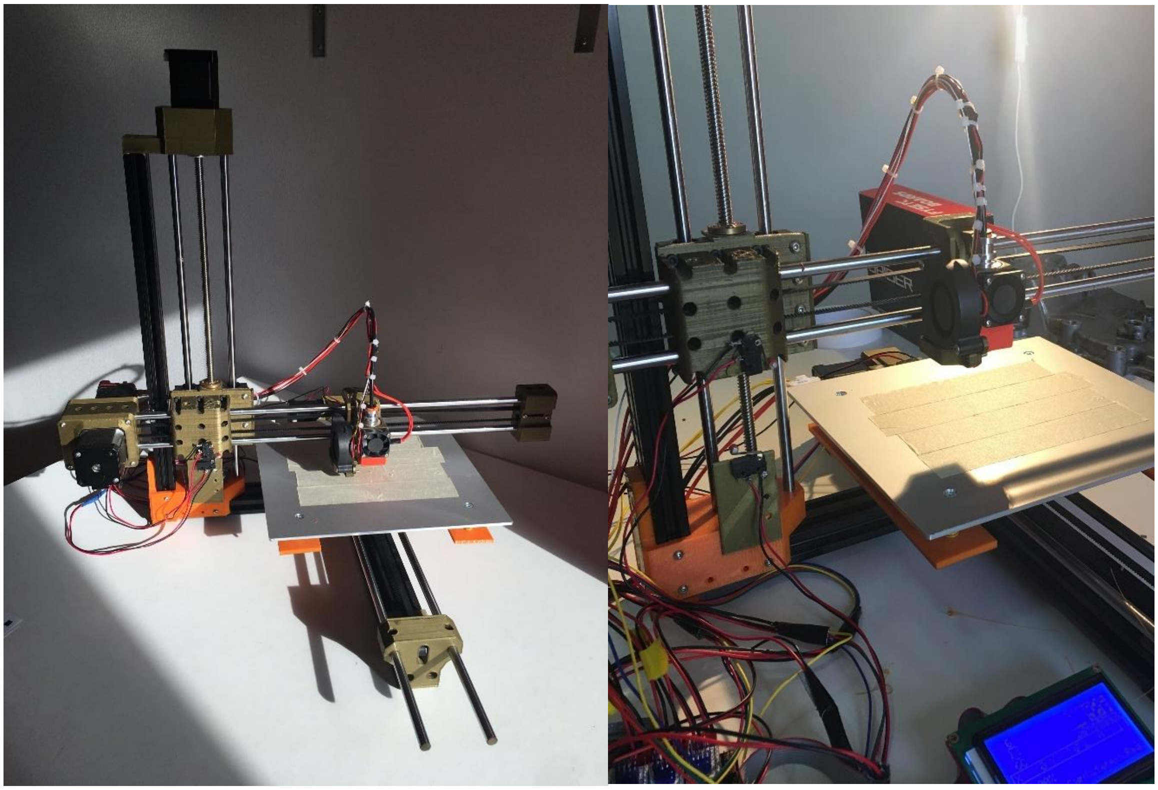


Figure 4: The left shows the completed cantilevered 3D printer, and the right shows a close of the nozzle assembly of the 3D printer. Some pieces on the 3D printer use an orange plastic as I had ran out of the bronze filament due to having extensive assembly and part reworks as I had not designed carefully enough.

2.3.2.2 Data-Driven Iteration

In senior year of high-school, as the team-lead of electrical and mechanical design of an electric car design team, I collected extensive data on battery performance, including voltage measurements, temperature readings, and discharge rates—to precisely calibrate our motor controller. This methodical data collection allowed us to extract maximum power from our battery system, giving us a competitive edge in races.

This experience reinforced that effective iteration isn't just about trying different approaches; it's about making informed adjustments based on quantifiable results and using this factoring in of the results to improve outcomes.

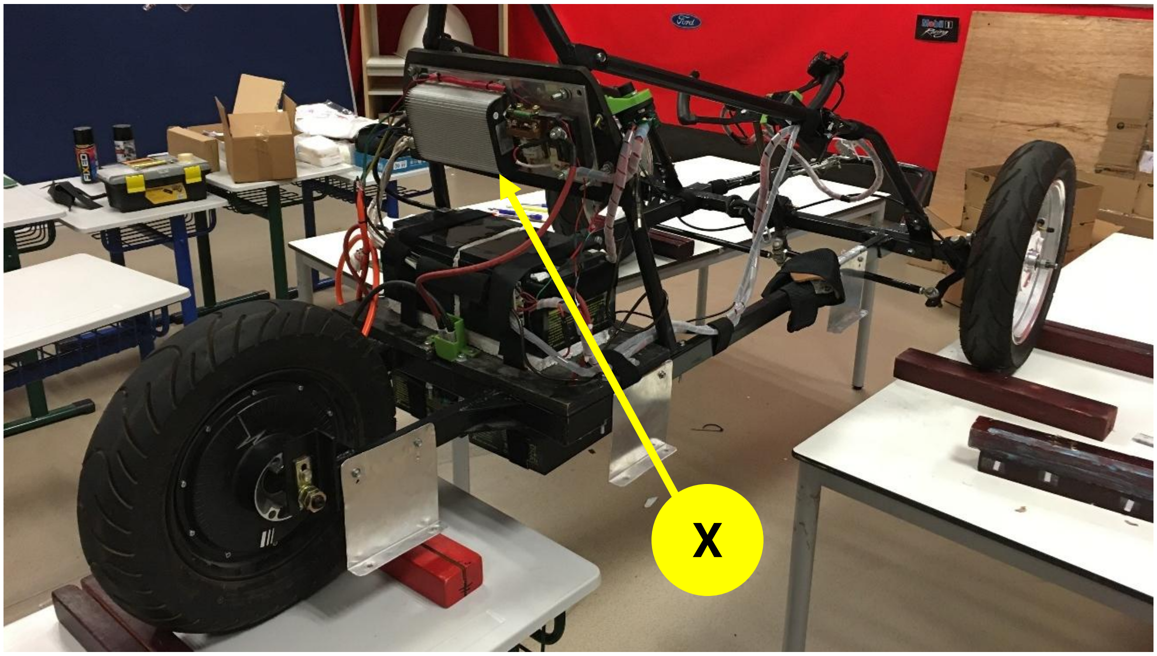


Figure 5: Electric car on tables ready for discharge tests and for further controller programming, controller is identified with arrow and circle denoted as “X”.

2.3.3 Representing

2.3.3.1 Collaborative Design and Unexpected Inspiration

When I created a 3D modeling course that was taught across 11 schools with approximately 2,700 eligible students, I assigned topology optimization studies as part of the curriculum as shown in figure 6. Topology optimization is a mathematical approach that distributes material within a design space to maximize performance under given constraints. I was consistently surprised to find that many students developed solutions superior to my own reference designs. Their diverse backgrounds and perspectives led them to approaches I hadn't considered, reinforcing the value of collaborative problem-solving and diverse viewpoints in engineering.

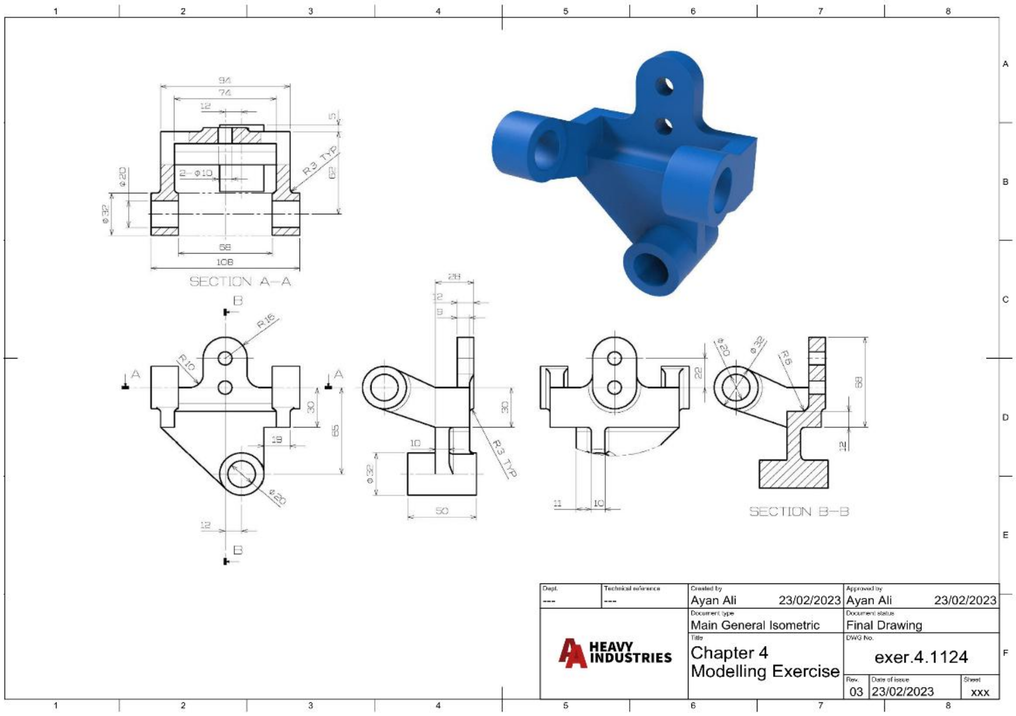


Figure 6: This figure shows exer.4.1124, this exercise was the 4th topology exercise assigned to students in my course in the second week of study.

3.0 Overview

The next three sections will describe the usages of concepts, tools, models, and frameworks throughout might engineering design process in three main projects, the CIV102 Matboard Bridge, Praxis I, and Praxis II. Figure 7 shows the relation of these CTMFs to the FDCR cycle.

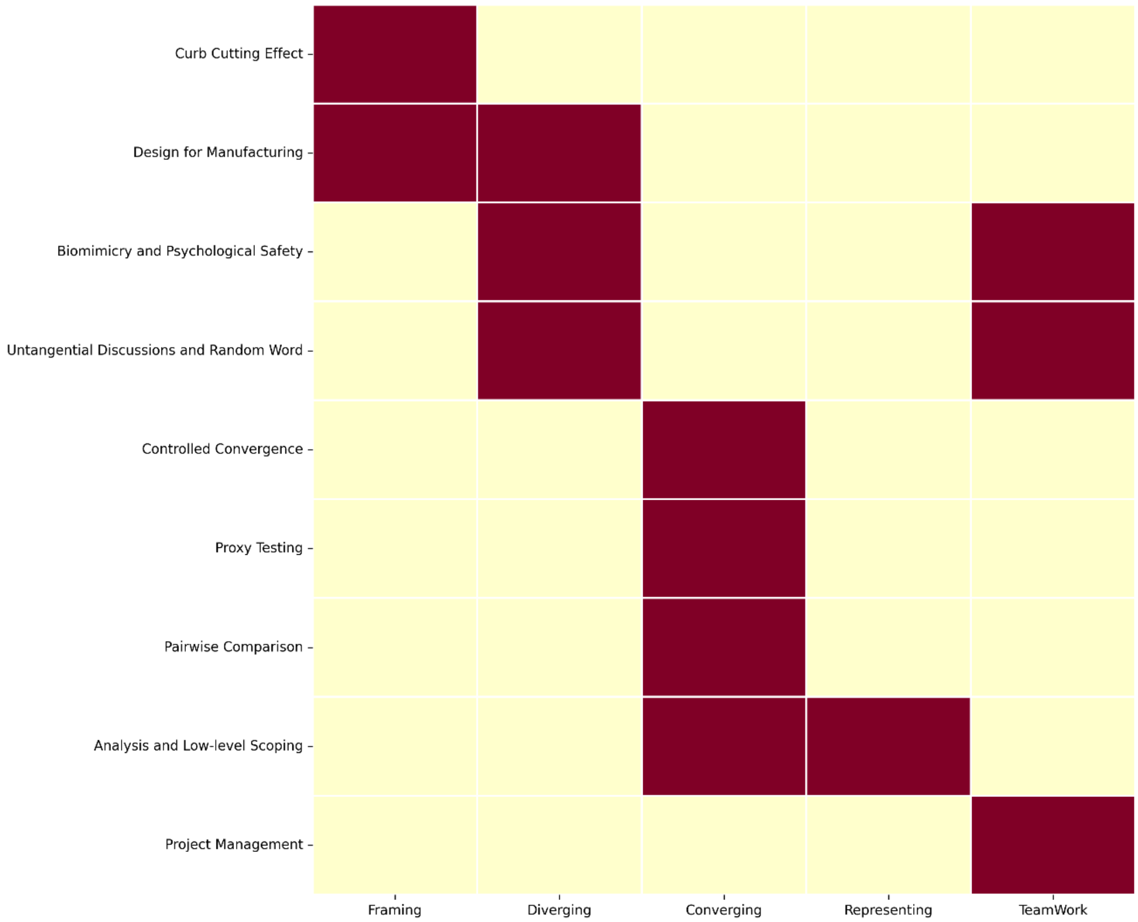


Figure 7: Relationship of the CTMFs of the three projects with respect to the FDCR cycle exemplify the complete nature of my analysis.

> **NOTE**
>
> *It should be noted that all Team member initials denoted as RvH, AF, JW for Praxis II; MI, NF for CIV102; and AS and AB for Praxis I. This was done out of privacy for said individuals.*

3.0 CIV102 Matboard Bridge

3.1 Design Summary

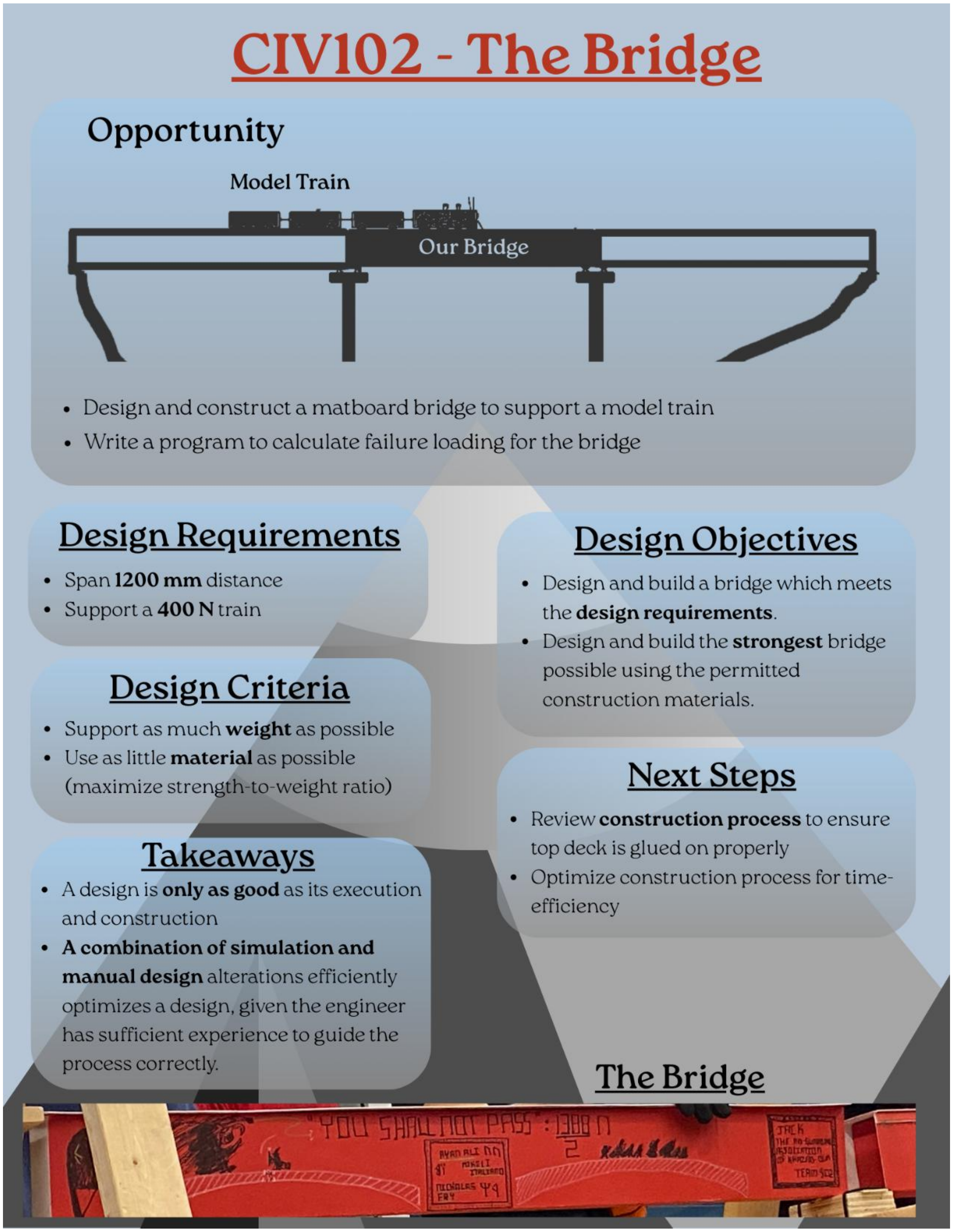
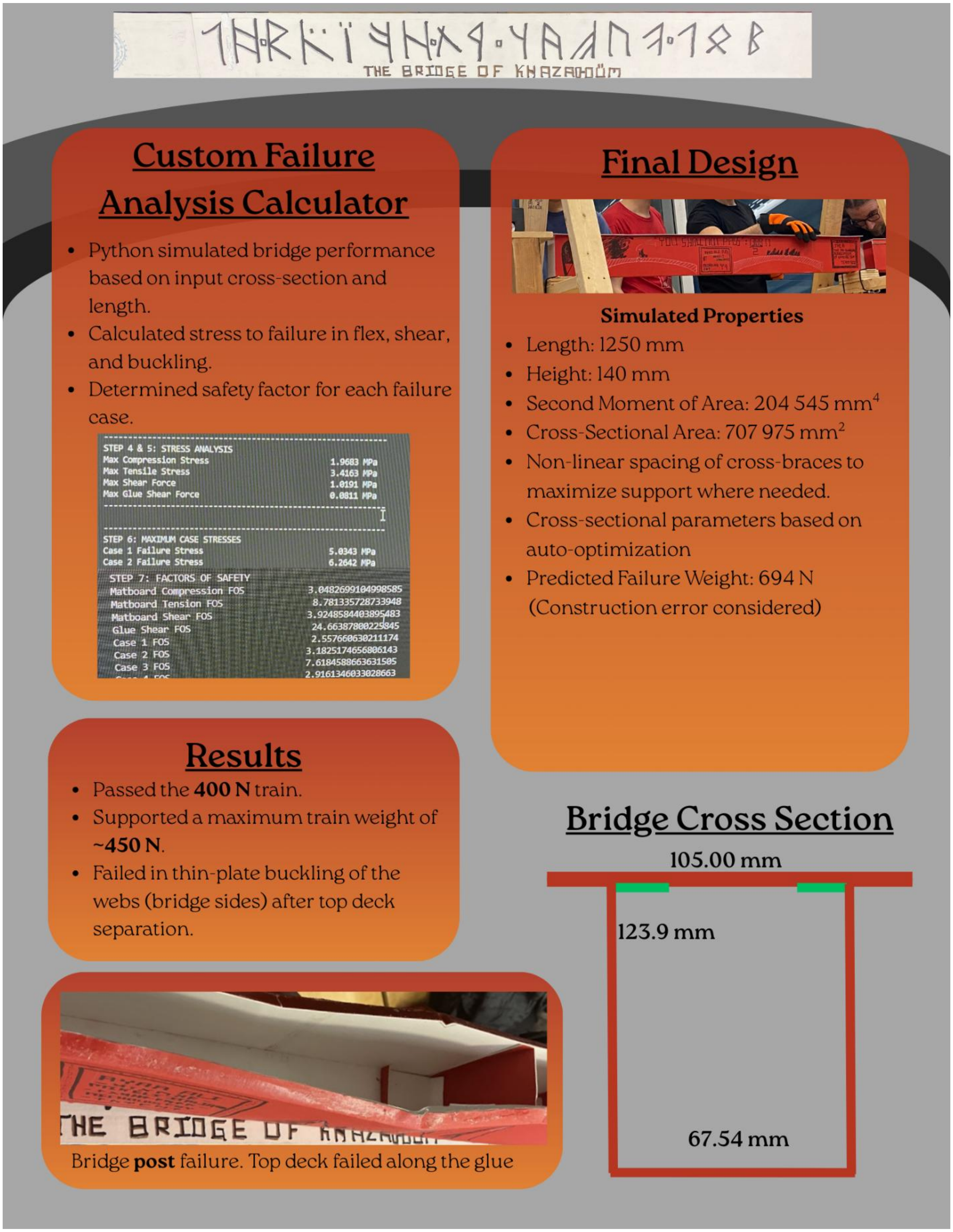


Figure 8: First page of the CIV102 Bridge one-pager.



THE BRIDGE OF KHAZADDÛM

Custom Failure Analysis Calculator

- Python simulated bridge performance based on input cross-section and length.
- Calculated stress to failure in flex, shear, and buckling.
- Determined safety factor for each failure case.

```
STEP 4 & 5: STRESS ANALYSIS
Max Compression Stress          1.9683 MPa
Max Tensile Stress              3.4163 MPa
Max Shear Force                 1.0191 MPa
Max Glue Shear Force            0.0811 MPa

STEP 6: MAXIMUM CASE STRESSES
Case 1 Failure Stress           5.0343 MPa
Case 2 Failure Stress           6.2642 MPa
STEP 7: FACTORS OF SAFETY
Matboard Compression FOS        3.0482699104998585
Matboard Tension FOS            8.781335728733948
Matboard Shear FOS              3.9248584403895483
Glue Shear FOS                  24.66387800225845
Case 1 FOS                      2.557660630211174
Case 2 FOS                      3.1825174656806143
Case 3 FOS                      7.6184588663631505
                                2.9161346033028663
```

Final Design

Simulated Properties

- Length: 1250 mm
- Height: 140 mm
- Second Moment of Area: 204 545 mm^4
- Cross-Sectional Area: 707 975 mm^2
- Non-linear spacing of cross-braces to maximize support where needed.
- Cross-sectional parameters based on auto-optimization
- Predicted Failure Weight: 694 N (Construction error considered)

Results

- Passed the **400 N** train.
- Supported a maximum train weight of **~450 N**.
- Failed in thin-plate buckling of the webs (bridge sides) after top deck separation.

THE BRIDGE OF KHAZADDÛM

Bridge **post** failure. Top deck failed along the glue

Bridge Cross Section

105.00 mm

123.9 mm

67.54 mm

Figure 9: Second page of the CIV102 Bridge one-pager.

3.2 Design Annotations

The CIV102 bridge project involved the construction of a matboard (a type of layered paper board) by applying our theoretical knowledge of designing bridge members to create a single-member bridge. The bridge would have a train (composed of heavy weights of around 200N) that would be rolled across the bridge.

It first involved a set of hand calculations which were then used to verify a computer program that I had programmed to ensure that the program was producing results that were in reality. See figure 10 for the output of the program.

```
------------------------------------------------------------
STEP 3: GEOMETRY
Bridge Length                           1250.0000 mm
Bridge Height                            140.0000 mm
Centroid X                                -0.0000 mm
Centroid Y                                26.3772 mm
Second Moment of Area                 2044545.2836 mm⁴

Diaphragms                                 8.0000

Matboard Area                         800000.0000 mm²

Cross Section Area Used               707975.0000 mm²
Area Left                              92025.0000 mm²

Void Area                               9109.4742 mm²
Diaphragm Area Used                    72875.7936 mm²
Area Left                              19149.2064 mm²
------------------------------------------------------------

------------------------------------------------------------
STEP 4 & 5: STRESS ANALYSIS
Max Compression Stress                     1.9544 MPa
Max Tensile Stress                         3.3935 MPa
Max Shear Force                            1.0133 MPa
Max Glue Shear Force                       0.0805 MPa
------------------------------------------------------------

------------------------------------------------------------
STEP 6: MAXIMUM CASE STRESSES
Case 1 Failure Stress                      5.0343 MPa
Case 2 Failure Stress                      6.2642 MPa
Case 3 Failure Stress                     14.7902 MPa
Case 1 Failure Stress                      5.0343 MPa
Case 2 Failure Stress                      6.2642 MPa
Case 3 Failure Stress                     14.7902 MPa
Case 4 Failure Stress                      2.3849 MPa
------------------------------------------------------------

------------------------------------------------------------
STEP 7: FACTORS OF SAFETY
Matboard Compression FOS          3.0700717579530545
Matboard Tension FOS               8.840521973167807
Matboard Shear FOS                 3.947506923239098
Glue Shear FOS                    24.836281889056423
Case 1 FOS                         2.575953540135206
Case 2 FOS                         3.205279479000007
Case 3 FOS                         7.567840794498288
Case 4 FOS                         2.353597011904006
```

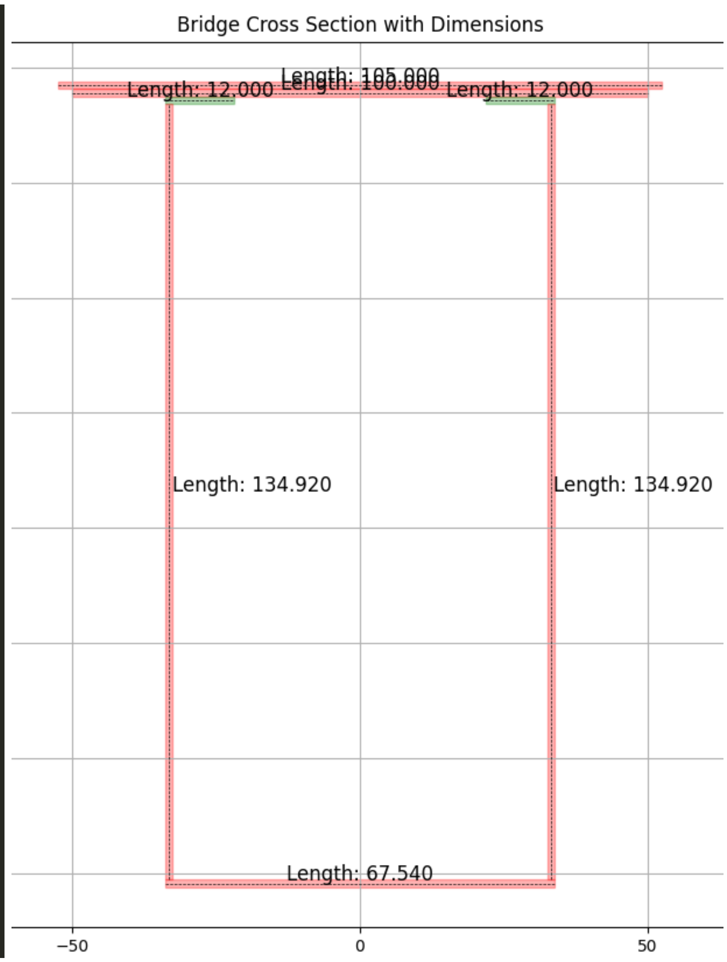


Figure 10: Shown on the left is a snippet of some of the output calculations that were used to inform our interations and also used to verify with hand-calculations. On the right is the cross-section of the proposed birdge.

I had later mechanized the process of creating iterations, as shown in Figure 11, once we realized that the height of the bridge, the top flange thickness, and the number of diaphragms was the critical metric in increasing the strength in the Case 4 Buckling which was the “weakest link” of the bridge.

3.3 CTMF 1 – Controlled Convergence

3.3.1 Definition of Controlled Convergence

Controlled convergence is the process of iteratively converging and diverging which allows for the ideation of a great number of possible solutions whilst not having too many that are unmanageable as they are regularly removed by way of convergence, this allows for new strains of divergence to get ever closer to the on “true” solution as discussed in section 2.2. [8]

3.3.2 Usage of the Controlled Convergence

In the case of the CIV102 bridge we used this sort of process through the entire design stages. In the beginning we used hand-calculations to inform the initial first iteration of the bridge design.

We then used these hand-calculations to ensure that the final computer program that we had made was producing results that were on the basis of reality. In iteration 6, we mechanized the process of iteration to produce all possible permutations finite number of available heights (20, 40, 60, 80, 100, 120, 140, 160, 180, 200), a finite number of top flange thicknesses (1.27, 2.54, 3.81, 5.08) as we cannot exceed the matboard area, and a finite number of diaphragms (1 to 20) as we cannot exceed the matboard area as shown in Figure 11.

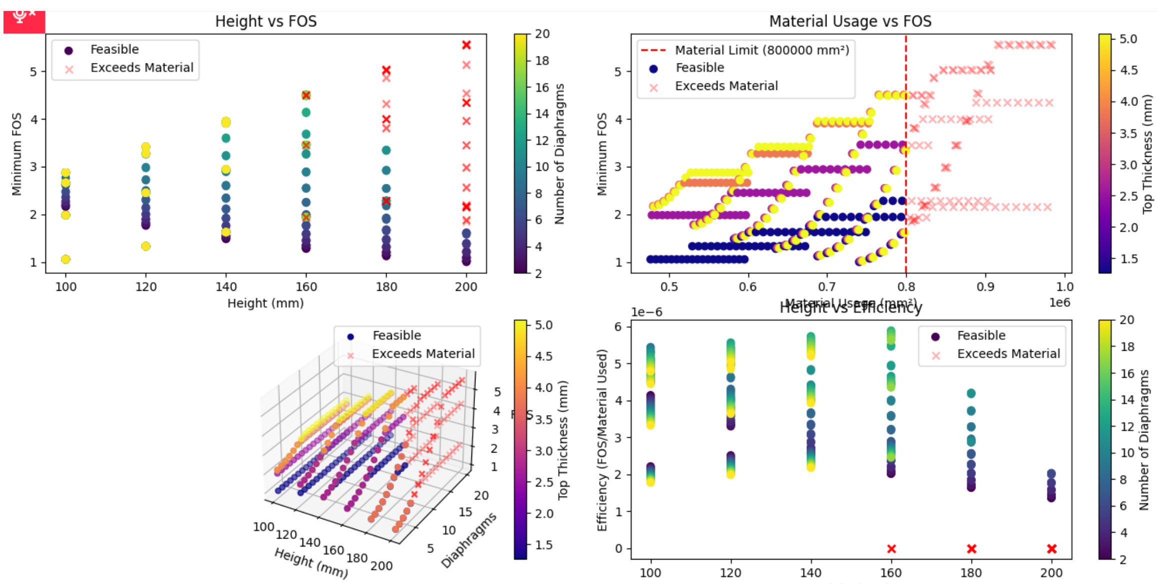


Figure 11: This figure shows all the permutations and the relations to the three main variables that were adjusted as well as the strength to weight ratio.

This closely aligns with my data-driven iteration design philosophy as it ensures that no stone is left unturned and the real true solution is sought after completely.

3.3.3 Key Takeaways of the Controlled Convergence

1. Controlled convergence is able to become mechanized, this means that it can be automated just like how I made the automated script to find all permutations of the remaining types of bridges. This closely aligns with my data-driven iteration design philosophy as it ensures that no stone is left unturned and the real true solution is sought after completely.

2. Controlled convergence allows us to get close to the final design ensuring that we explore the entire design space whilst not spending too much time on designs that have glaring issues or would fundamentally fail the requirements.

3.3.4 Shortcoming of the Controlled Convergence

1. The main shortcoming of the process of controlled convergence is that without any data to drive convergence especially at such a stage where proxy testing is not possible due to no prototypes being available (such as in Praxis I) the potential of bias can be high. It is important to ensure that team members do not engage in group thought and make their own opinions and then later convene and decide for an ultimate decision.

3.4 CTMF 2 – Project Management

3.4.1 Definition of Project Management

Project management is the application of knowledge, skills, tools, and techniques to project activities to meet project requirements. It involves initiating, planning, executing, monitoring, and closing a project in order to achieve specific goals within given constraints such as time, budget, and resources. Effective project management ensures that a team's work is aligned with its objectives and delivered in an organized, efficient, and predictable manner. [7]

3.4.2 Usage of Project Management

In the case of the CIV102 bridge project a key feature of our management of the course was the use of a time log where each of us in the group logged how much time we spent on a given task and were able to track our final and internal deadlines with respect to how progress was being made.

As shown in figure 12, when a given task was complete, the box was turned green; if the task was in-progress the task was given a blue color; if the task was late it was given an orange color; and then there was a bar the moved along the length of the time log to show where we should be as a team with respect to the current date.

Tasks	Internal Deadline	Submission Deadline	Mikeli	Nick	Ayan
Preliminary	10/29/2024	---	1.5	1.5	2
Deliverable I Preliminary Meeting Includes Reading Design Document, Assigning Tasks, and Analyzing the rest of the project	11/3/2024	---	1	1	1
Find storage and building space	11/5/2024	---	0.5	0.5	0.5
Pick up build material	13/13/2024	---	---	---	0.5
Deliverable 1	11/9/2024	11/11/2024	3	2	1.2
SFD and BMD	11/9/2024	11/11/2024	0.5	1	---
Centroid and Second Moment of Area	11/3/2024	11/11/2024	1.5	---	---
FOS against flexural tension/compression failure	11/4/2024	11/11/2024	0.33	---	---
First Review	11/04/2024	11/11/2024	0.66	1	---
Second Review	11/05/2024	11/11/2024	---	---	1.2
Team Dynamics Survey	11/3/2024	11/11/2024	0.1	0.1	0.1
Design Report - Total	11/25/2024	11/25/2024	3.5	6	11.5
Introduction	11/25/2024	11/25/2024	---	0.5	---
Preliminary Discussion	11/17/2024	11/25/2024	1	1	1
Code review and design report analysis	---	11/25/2024	0.5	0.5	-
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Figure 12: A snapshot of the time log to show our current progress as the CIV102 bridge project went on. The red line is the date bar and shows what our current progress should be with respect to today's date.

We were able to then inspect how many greens, oranges, and blues were behind the date bar to determine if we were on track and how much we would need to pivot to make our deadlines fit in with our other coursework.

3.4.3 Key Takeaways of the Project Management

1. A time log for this project seemed to be most appropriate as it allowed us to track how much time was being spent on each section of the project. Since we had not past experience on the sort of tasks we would be doing (especially the construction), the time log allowed for us to reallocate work if something was taking longer than expected.

2. A clear set of internal deadlines ensured that we able to complete everything ahead of time and had time to spare in case something took longer than expect or there were unexpected commitments outside of the CIV102 course.

3. Assigned work ensured that responsibility was taken for work and so it was completed to a higher standard than in the case of assigning work to the entire group and hoping that work was completed by someone and that work was automatically assigned.

3.4.4 Shortcoming of the Project Management

1. A time log requires integrity of group members in the project, in a non-aligned group this may become infeasible and may actually result in points of friction, in this scenario it is best to consider alternative project management tools such as a team Gannt Chart.

3.5 CTMF 3 – Design for Manufacturing

3.5.1 Definition of Design for Manufacturing

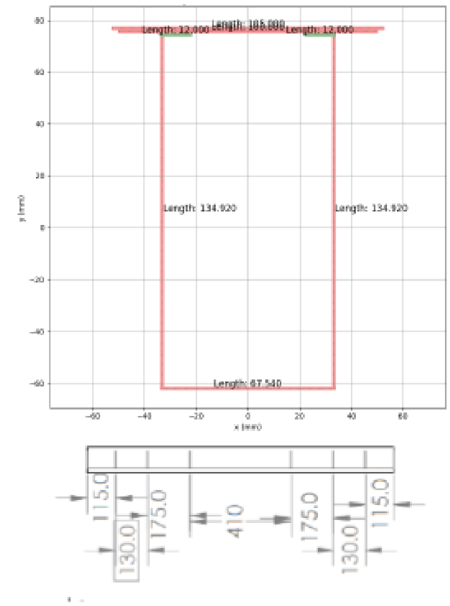
Design for Manufacturing (DFM) is the engineering practice of designing products in such a way that they are easy to manufacture. It involves considering manufacturing processes, material choices, tolerances, and assembly methods early in the design phase to reduce complexity and waste. [7, 8]

3.5.2 Usage of the Design for Manufacturing

In the case of the CIV102 project, we very keenly considered the available matboard to us to use, if we exceed this area we could not build the bridge as shown in figure 13 we used an efficiency calculation which took ratio of the maximum load the bridge could hold with respect to the total area used.

DESIGN FINAL

CROSS SECTION



GEOMETRY

Length	mm	1250.
Height	mm^4	140.0
Second Moment of Area	mm^2	2044545.2836
Area Used by Cross-Section	mm^2	707975.0000
Diaphragms		8
Diaphragm Spacing	mm	NON LINEAR
Area Used by Diaphragms	mm^2	72875.7936
Final Area Remaining	mm^2	19149.2064
Efficiency	FOSx10^6/mm^2	3.93

STRESSES AND FOS

	Flexural		Shear		Thin Plate Buckling			
	Compr.	Tension	Centroid	Glue	Case 1	Case 2	Case 3	Case 4
Stress	1.9544	3.3935	1.0133	0.0805	5.0343	8.2591	14.7902	
FOS	3.0700	8.8405	3.9475	24.8362	10.3041	3.2052	7.5678	MIN 3.38

DIAPHRAGMS AND CASE 4 FOS

Diaphragm Number	1	2	3	4	5	6	7	8
Relative Position	0	115.0	245	420	830	1005	1135	1250.
FOS	3.56	3.64	3.45	3.38	3.38	3.45	3.64	3.56

DESIGN CHANGES

Design Change	Justification
Rounded values	Final values are all rounded.

Figure 13: This figure gives an overview of the final design, highlighted in yellow is the efficiency rating and the total are used by the bridge, diaphragms, and the area that is remaining.

Moreover, we also had to consider the layups of the material as simply considering the area was not entirely enough to build the bridge as we would need large continuous sections of matboard. For this we used a custom programmed python tool to be able to see how we would be able to lay out the pieces on the matboard as we integrated on our design as shown in figure 14.

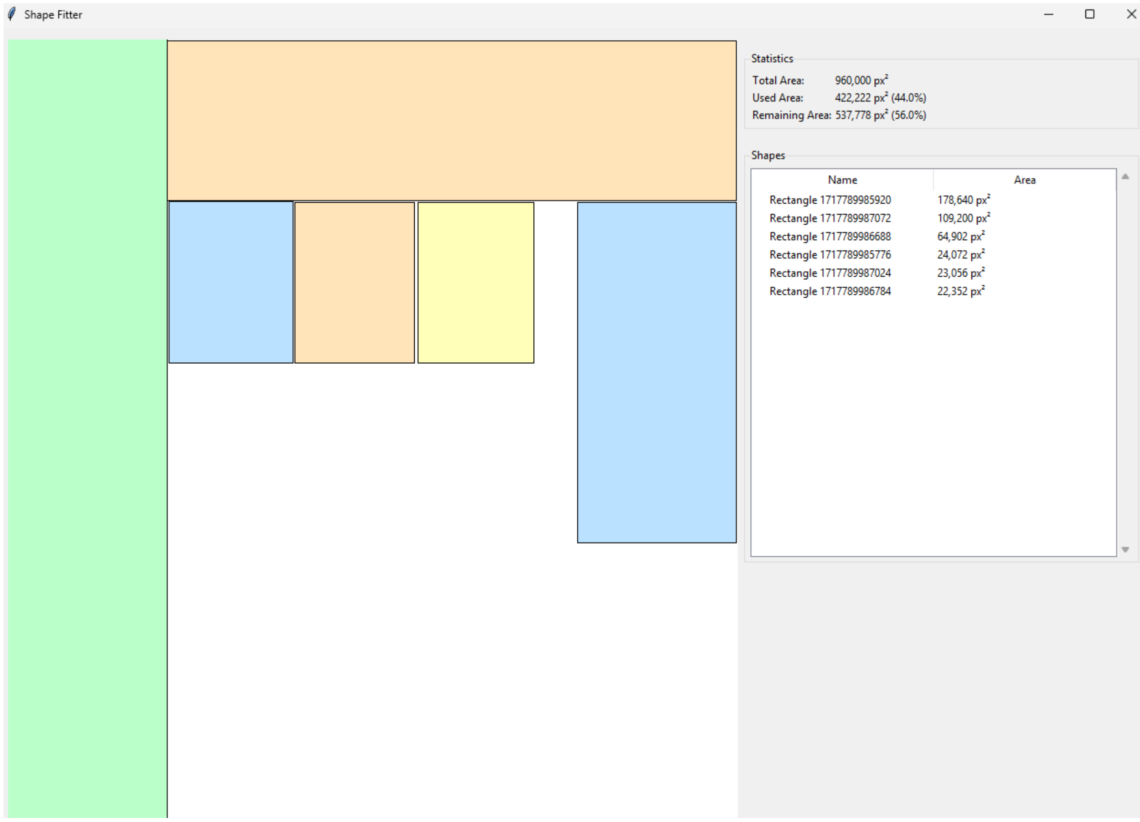


Figure 14: Shows a quick python script for laying out the cutouts for the bridge on a large matboard piece, this allowed for the quick adjustment and checking of designs rather than hand drafting.

3.5.3 Key Takeaways of Design for Manufacturing

1. The efficiency calculation not only ensured optimal use of the limited matboard but also aligned with our broader engineering philosophy of reducing waste and negative impacts on society and the environment. The number was also an important factor in terms of the success of the final bridge as the strength-weight ratio was prioritized when we were given this project.

3.5.4 Shortcoming of Design for Manufacturing

1. While DFM forced us to stay within real-world constraints, it sometimes limited creative exploration. Some potentially stronger or more innovative geometries had to be discarded early because they were not compatible with the manufacturing material or layout.

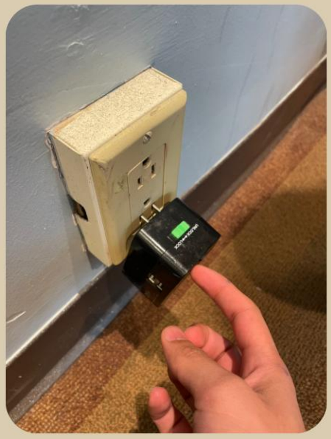
2. DFM can require significant upfront effort as given by the additional features that we had to integrate with our computer program (and the secondary side program for the layups) which may not be practical in time-constrained or lower-resourced teams. In such cases, simpler approximation methods may be more appropriate.

4.0 Praxis I – Loose Plugs in Wall Sockets

4.1 Design Summary

Electromagnet Plug Holder for Loose Plugs

Opportunity



The device shall solve the problem of loose connections of plugs to wall sockets faced by Engineering Science students on campus and at residence. Specific locations include the following: Chestnut Residence, UofT Libraries frequented by Engineering Science Students, the EngSci Common Room, MyHall, McLennan Physical Laboratories, and Bahen Center for Information Technology.

Design Requirements

- Shall have a contact resistance below 10 mΩ to ensure that there is no chance of fire and in contact
- No Adhesive residue is left on the wall socket

Design Criteria

- Support the **maximum plug size** possible
- Whilst **minimizing contact resistance** and **deployment time**

Design Objectives

- Design a system to meet the Design Requirements
- Design a system that has an engagement force between 10N and 30N
- Design a system that a volume less that 150 cm3
- Design a system with a deployment time no longer than 6 seconds
- Design a system that has a contact short hardness of less that 70A
- Design a system that is able to receive minimum plug dimensions of 10cm x 7.5cm x 6cm

Next Steps

- Implement a real-world design rather than low-fidelity prototypes to test the actual electromagnetic mechanism behind design
- Research whether the electromagnetic effect will cause heating or the like

Figure 15: First page of the Praxis I one-pager.

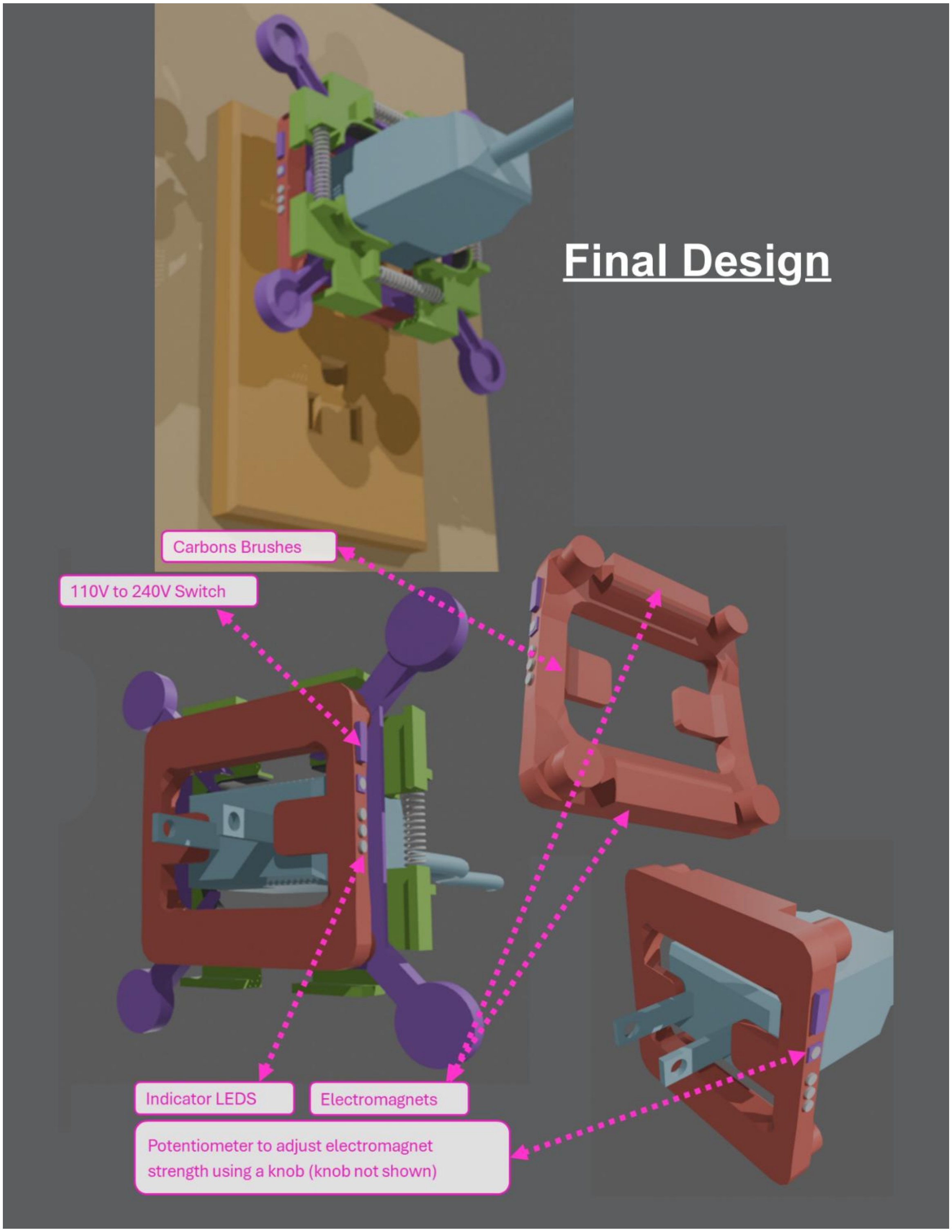


Figure 16: Second page of the Praxis I one-pager.

4.2 Design Annotations

We had chosen the Splartz of loose plugs in wall sockets on spaces used by Engineering Science students on campus and at Chestnut Residence. After choosing this Splartz and preparing a comprehensive set of requirements we began the diverging, pre-converging, and converging stages of our design process as shown in figure 17.

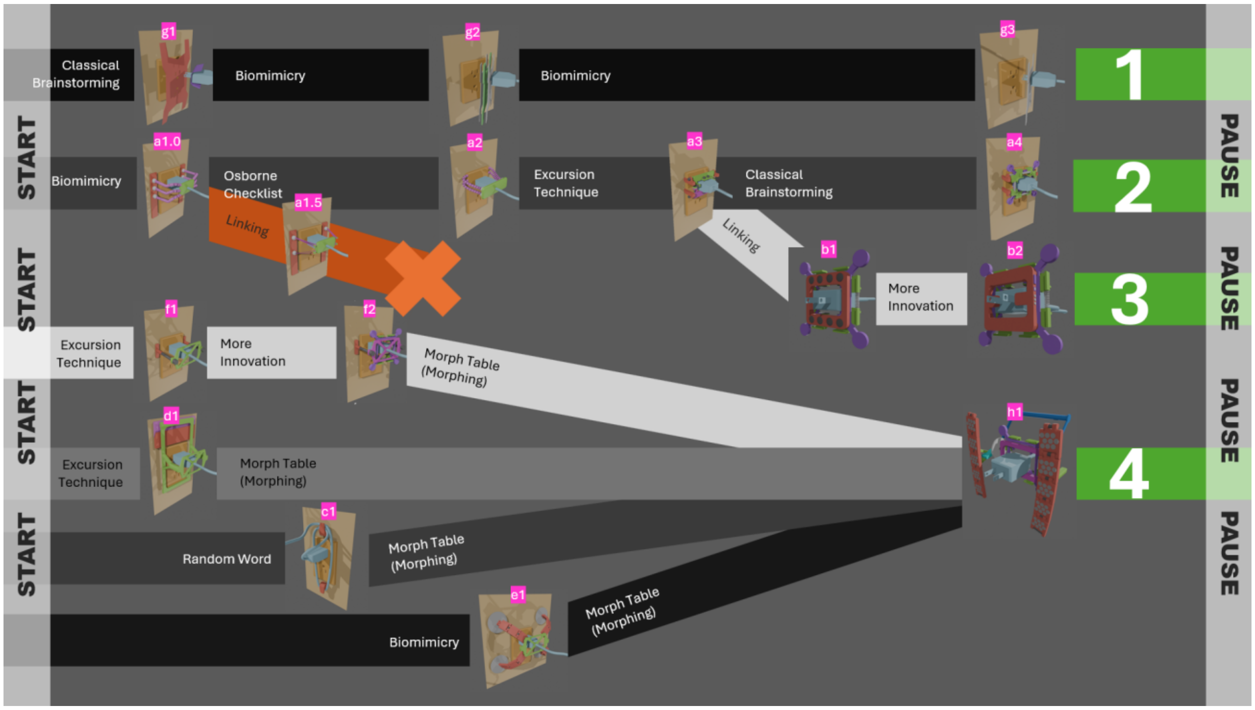


Figure 17: This figure shows our stages of diverging, pre-converging, diverging, etc. and how we morphed certain designs into others as part of our Alpha development.

After we had 4 final designs to choose from we began proxy testing these designs with respect to 6 critical metrics as outlined in the first page of the one-pager in figure 15. We recorded (available here: https://www.youtube.com/watch?v=2SzLAbtiBz8) our proxy tests on video.

We ultimately settled on the final design that uses an electromagnet that is powered by the wall socket itself and latches onto the internal metal structure of the wall socket as shown in figure 16.

4.3 CTMF 1 – Psychological Safety and Biomimicry

4.3.1 Definition of Psychological Safety

Psychological Safety refers to a shared belief among team members that the team is a safe environment for interpersonal risk-taking. It allows individuals to speak up with ideas, questions, concerns, or mistakes without fear of embarrassment, rejection, or punishment. [8]

4.3.2 Definition of Biomimicry

Biomimicry is an approach to innovation that seeks sustainable solutions by emulating nature's time-tested patterns and strategies. It involves observing and replicating biological forms, processes, and ecosystems to solve human design challenges. [8]

4.3.3 Psychological Safety Results in Humor and Aids Diverging

In the early phases of the Alpha Development Process, we established psychological safety by individually recording and then sharing our personal values as shown in figure 18, key among this exercise was the discovery that all team members shared a common value group centered around humor.

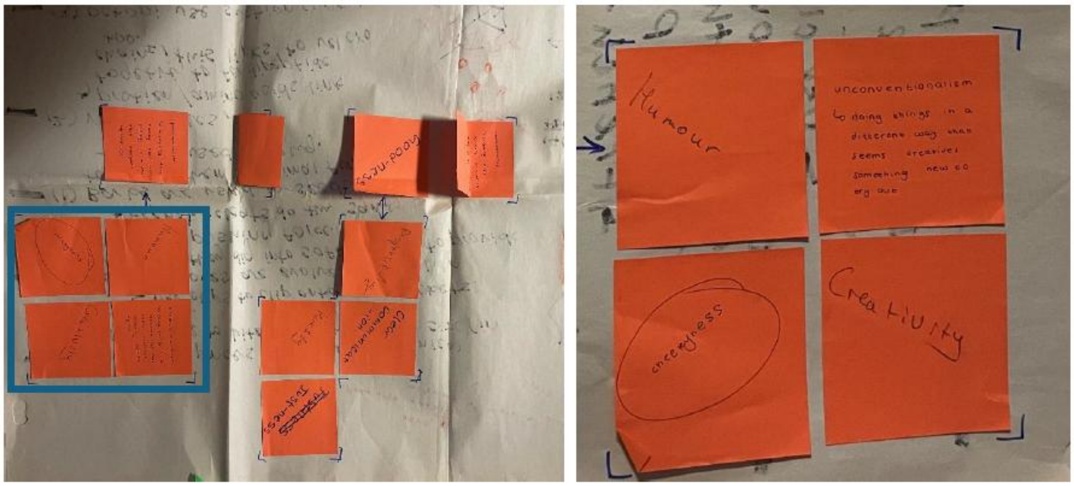


Figure 18: On the left is our teamwork values group together into related “value groups”, on the right is a zoom in of the humor value group.

Recognizing this early on allowed our team to foster an environment where no idea was “too out there” to be heard, and this became instrumental in promoting divergent thinking.

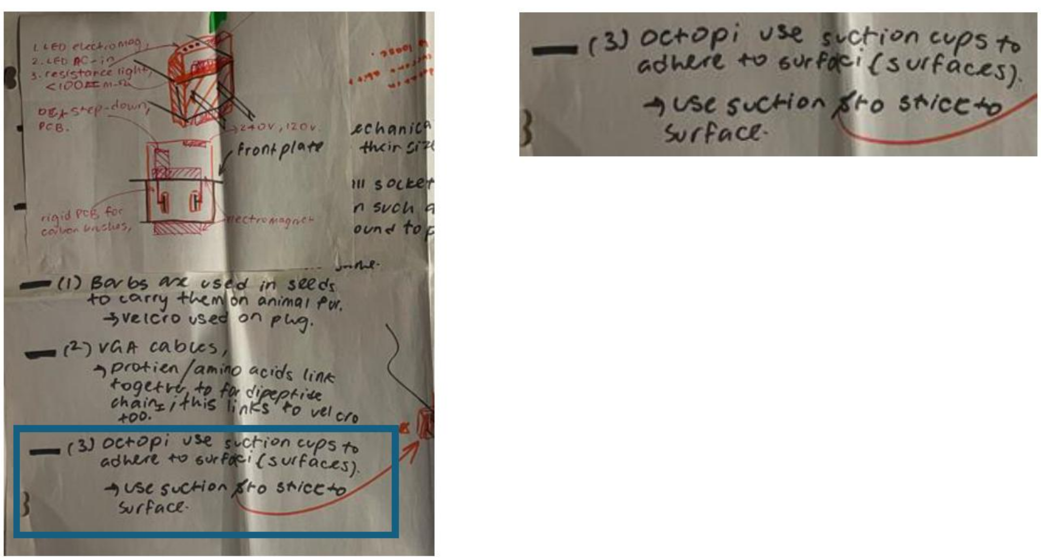


Figure 19: Shows the ideation of the “octopi surfaci” stage.

The incorporation of humor into ideation made the team more open to exploring "wild" ideas that might otherwise have been dismissed. For instance, when exploring possible plug designs using biomimicry, one team member suggested using octopus suction cups to help a plug adhere to a wall socket—a concept that emerged from the humorous idea of "octopi surfaci" (see figure 19). Although the initial suggestion was light-hearted, it triggered a productive stream of iterations that further explored the design space and led to more viable concepts.

4.3.4 Key Takeaways of this Effect

1. Early alignment on shared values such as humor helped establish psychological safety within the team, which was critical in fostering an open and creative ideation process.

2. The use of humor in a psychologically safe environment enabled the team to explore unconventional ideas—such as biomimetic suction cups—that sparked further iteration and deeper exploration of the design space.

4.3.5 Shortcomings of Humor as a Team Norm

1. Humor can sometimes lead to miscommunication or exclusion, especially if all team members do not relate to the same type of humor or feel equally comfortable expressing themselves in that way.

2. While helpful for idea generation, humor can become distracting or reduce focus during later design phases where critical evaluation and precision are required.

4.4 CTMF 2 – Pairwise Comparison

4.4.1 Definition of Pairwise Comparison

Pairwise Comparison is a qualitative evaluation method in which design alternatives are compared directly in pairs. Each pair is examined to determine which option better meets the design requirements or criteria. This process helps to establish a ranking order by identifying relative strengths and weaknesses without necessarily quantifying the magnitude of differences. [8]

4.4.2 Usage of the Pairwise Comparison

To begin our final convergence process we decided to start of with a high-level pairwise comparison to identify designs that were in close proximity with regard to their level of meeting the design requirement and criteria, as shown in figure 20.

	Magnetron	Octopi Suction	Spring Clamps	Nanotape	Total
Magnetron	-	0	1	1	2
Octopi Suction	0	-	1	1	2
Spring Clamps	0	0	-	1	1
Nanotape	0	0	0	-	0

Figure 20: Each design here is compared to the other design using a pairwise comparison method, the magnetron design corresponds to design b2 from figure X, octopi suction is h1, spring clamps is a4, and nanotape is g3.

4.4.3 Key Takeaways of Pairwise Comparison

1. Pairwise comparison enables a direct assessment between two designs at a time, simplifying the decision-making process by breaking down complex evaluations into manageable, binary decisions.

4.4.4 Shortcoming of Pairwise Comparison

1. The main issue with pairwise comparison is that it does not tell us how big the difference is between two designs, it only tells us the "sign" of the difference, that is, whether it is in favor of one design or the other. It is therefore required to use this tool in conjunction with a measurement matrix and Pugh chart and to not jump to conclusions regarding ties in the pairwise or even losses in the pairwise comparison.

2. With this in mind, pairwise comparison is then only useful on its own when it is known that the designs are quite close together and so ties are actual real ties, and losses are real losses.

4.5 CTMF 3 – Proxy Testing

5.4.1 Definition of Proxy Testing

Proxy testing is an indirect evaluation method where "mock" tests or simulations are used to assess critical performance metrics that are difficult to measure directly. By employing representative test conditions, proxy testing provides insights into how a design might perform under actual operational conditions without the need for full-scale or real-world testing.

5.4.2 Usage of the Proxy Testing

As part of our video (see above), we proxy tested some of critical metrics that were not able to reasonably obtained by way of calculation or secondary research, as shown in figure 21.

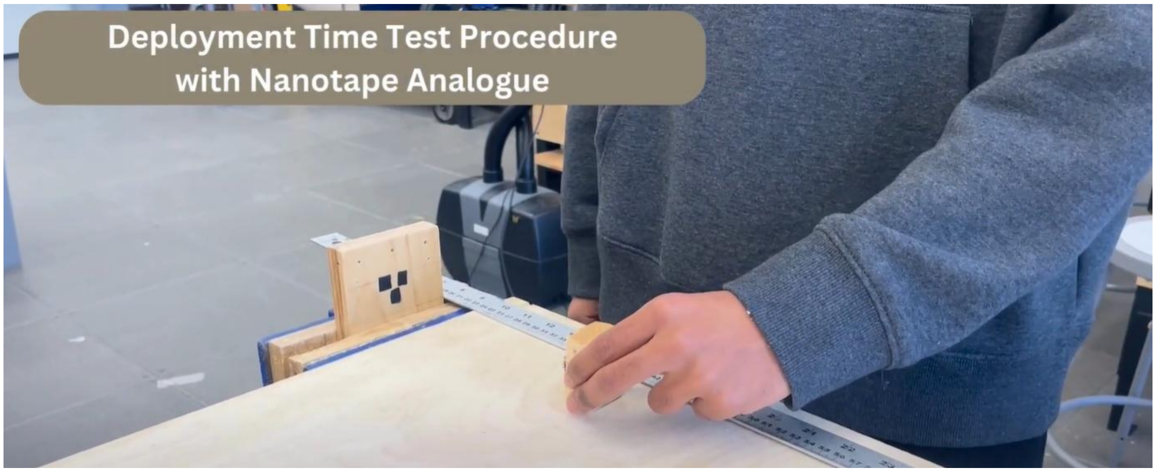


Figure 21: Top shows the deployment time test procedure for the nanotape analogue, bottom shows the engagement force test procedure for nanotape analogue.

This aligns closely with my values as data-based iteration is incredibly important if we want a successful final solution.

5.4.3 Key Takeaways of Proxy Testing

1. Proxy testing allows for the estimation of performance characteristics that are otherwise challenging to measure directly. This approach provides valuable data to inform design decisions when direct measurement is impractical.

2. Proxy testing serves as a practical check on theoretical predictions, ensuring that simulation-based or calculated results align closely with real-world behavior. This dual approach increases confidence in the final design.

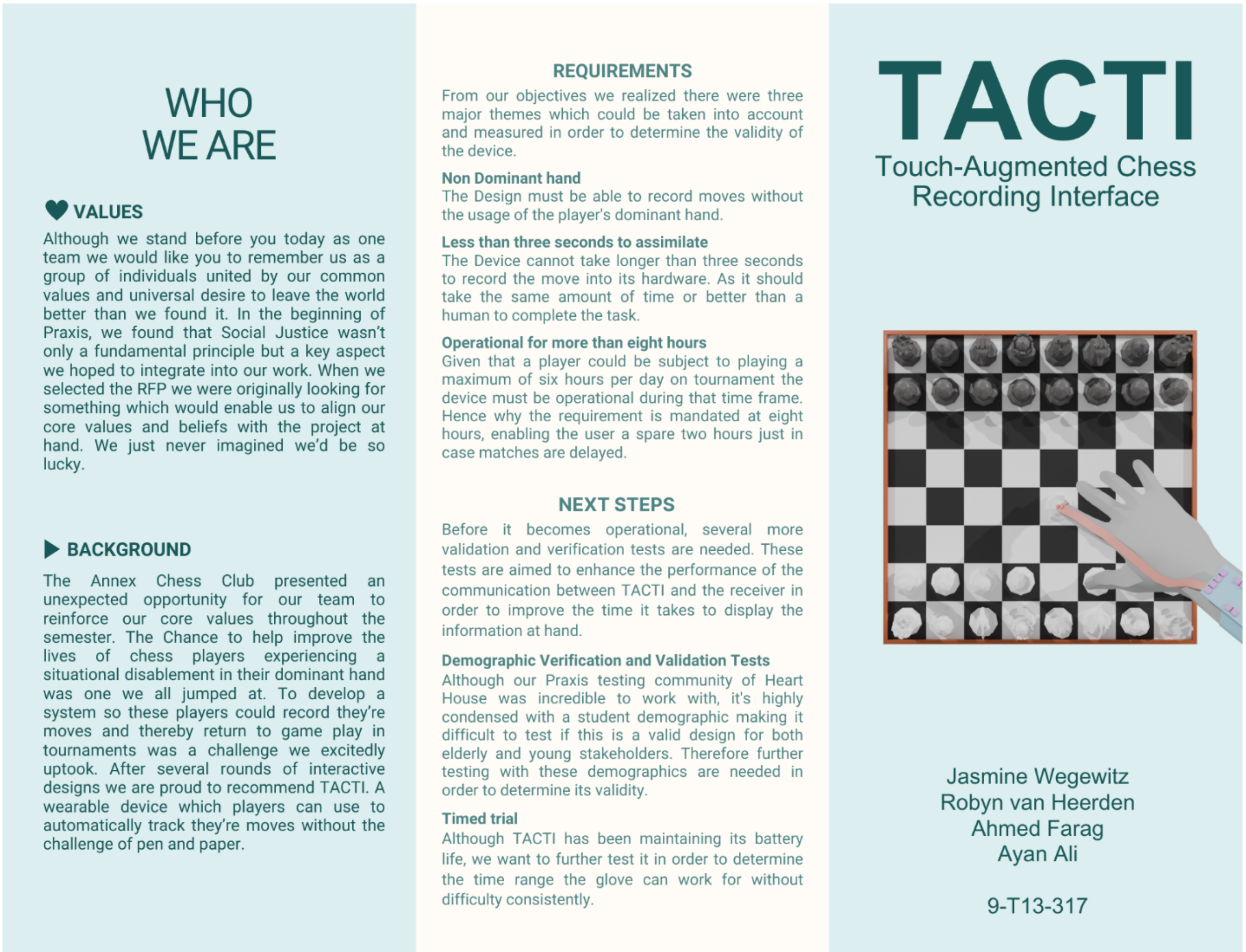
5.4.4 Shortcoming of the Proxy Testing

1. Proxy tests may not capture all the nuances and complexities of actual operational environments, potentially leading to discrepancies between test outcomes and real-world performance. As a result, it should ideally be supplemented with more rigorous or direct testing methods to fully validate design performance, adding an extra layer of effort and resource investment.

2. The effectiveness of proxy testing relies on the assumption that the mock conditions are an accurate representation of reality. If the test conditions diverge significantly from actual use, the conclusions drawn may be misleading.

5.0 Praxis II – Chess-Move Recording Device

5.1 Design Summary



WHO WE ARE

VALUES

Although we stand before you today as one team we would like you to remember us as a group of individuals united by our common values and universal desire to leave the world better than we found it. In the beginning of Praxis, we found that Social Justice wasn't only a fundamental principle but a key aspect we hoped to integrate into our work. When we selected the RFP we were originally looking for something which would enable us to align our core values and beliefs with the project at hand. We just never imagined we'd be so lucky.

BACKGROUND

The Annex Chess Club presented an unexpected opportunity for our team to reinforce our core values throughout the semester. The Chance to help improve the lives of chess players experiencing a situational disablement in their dominant hand was one we all jumped at. To develop a system so these players could record they're moves and thereby return to game play in tournaments was a challenge we excitedly uptook. After several rounds of interactive designs we are proud to recommend TACTI. A wearable device which players can use to automatically track they're moves without the challenge of pen and paper.

REQUIREMENTS

From our objectives we realized there were three major themes which could be taken into account and measured in order to determine the validity of the device.

Non Dominant hand
The Design must be able to record moves without the usage of the player's dominant hand.

Less than three seconds to assimilate
The Device cannot take longer than three seconds to record the move into its hardware. As it should take the same amount of time or better than a human to complete the task.

Operational for more than eight hours
Given that a player could be subject to playing a maximum of six hours per day on tournament the device must be operational during that time frame. Hence why the requirement is mandated at eight hours, enabling the user a spare two hours just in case matches are delayed.

NEXT STEPS

Before it becomes operational, several more validation and verification tests are needed. These tests are aimed to enhance the performance of the communication between TACTI and the receiver in order to improve the time it takes to display the information at hand.

Demographic Verification and Validation Tests
Although our Praxis testing community of Heart House was incredible to work with, it's highly condensed with a student demographic making it difficult to test if this is a valid design for both elderly and young stakeholders. Therefore further testing with these demographics are needed in order to determine its validity.

Timed trial
Although TACTI has been maintaining its battery life, we want to further test it in order to determine the time range the glove can work for without difficulty consistently.

TACTI

Touch-Augmented Chess Recording Interface

Jasmine Wegewitz
Robyn van Heerden
Ahmed Farag
Ayan Ali

9-T13-317

Figure 22: First page of the Praxis II showcase one-pager.

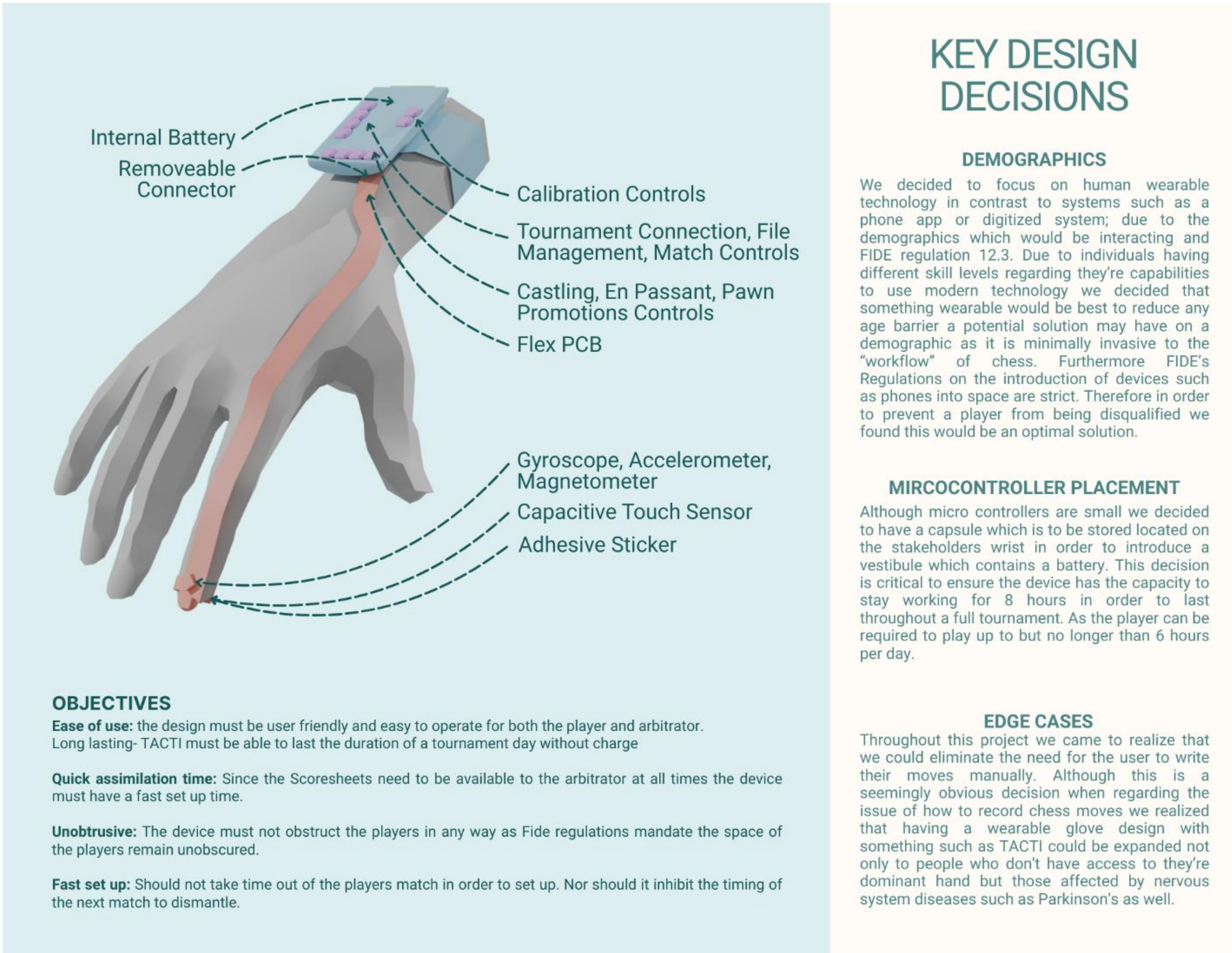


Figure 23: Second page of the Praxis II showcase one-pager.

5.2 Design Annotations

After receiving our first choice RFP – the chess RFP, we began in earnest with our diverging process as exemplified by the figure 24.

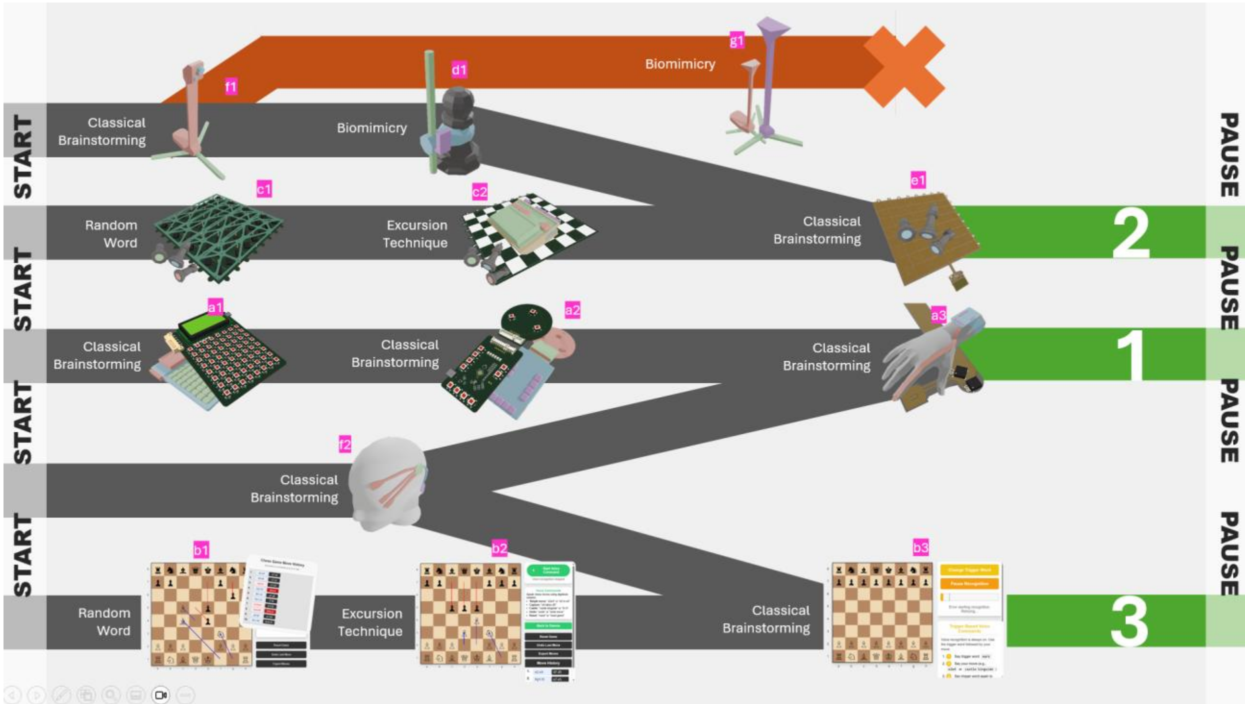


Figure 24: This figure shows our stages of diverging, pre-converging, diverging, etc. and how we morphed certain designs into others as part of our Beta development.

During this time we had a keen awareness of the complexity of a given design and then decided to scope out the designs in completion as show in appendix 7.1 and in figures X and X.

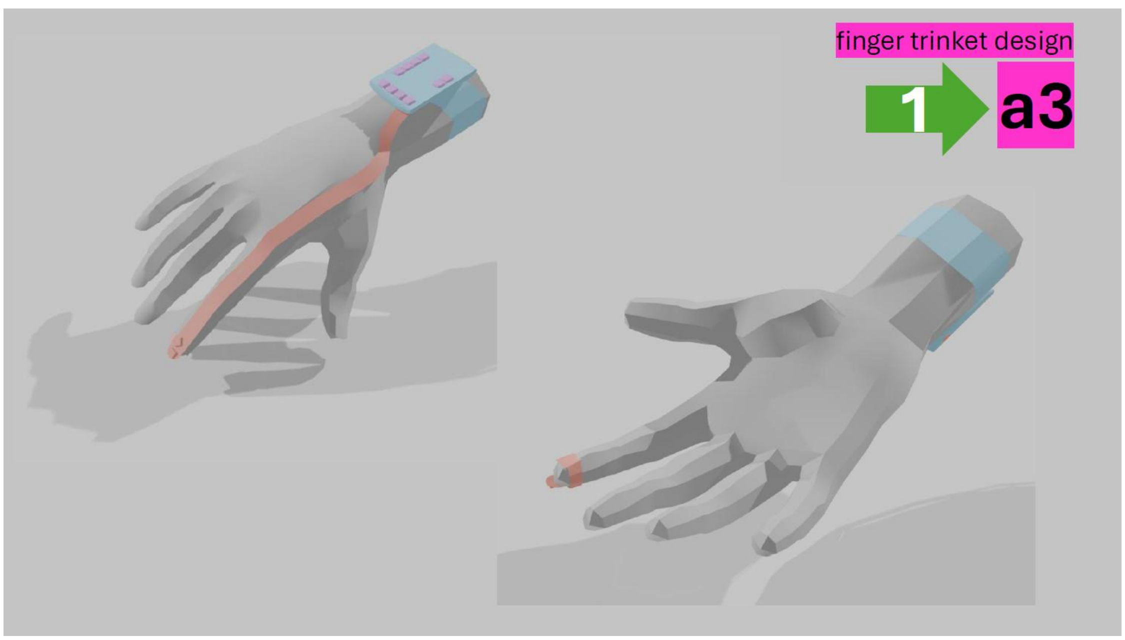


Figure 25: This image shows the TACTI medium fidelity Cad model so that we were able to scope out the way the actual device looked.

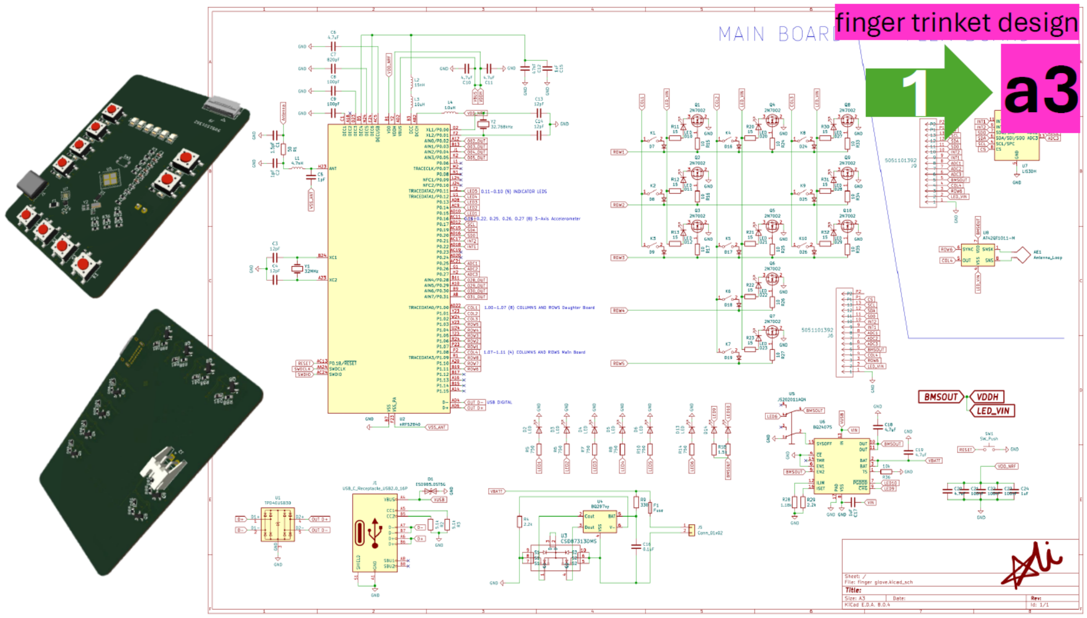


Figure 26: On the left is the CAD model of the main wrist-mounted control unit and on the right is the actual electronica schematic for said PCB.

We then converged onto the design labelled a3 in figure 24 by way of technical analysis and comparison to the requirements that we had rescoped after receiving our RFP. Shown in figure 27 is the final, Tacti (Touch-Augmented Chess Transcription Interface), it utilizes inertial navigation to track the index finger's position accurately. Upon detecting touch, it records the initial and release positions to determine the chessboard position, converting this data into algebraic notation (e.g., P-e2e4) through a set of algorithmic rules. Tacti offers significant value to stakeholders compared to other chess recording devices due to its superior accuracy, FIDE (Fédération Internationale des Échecs) compliance, and versatility.

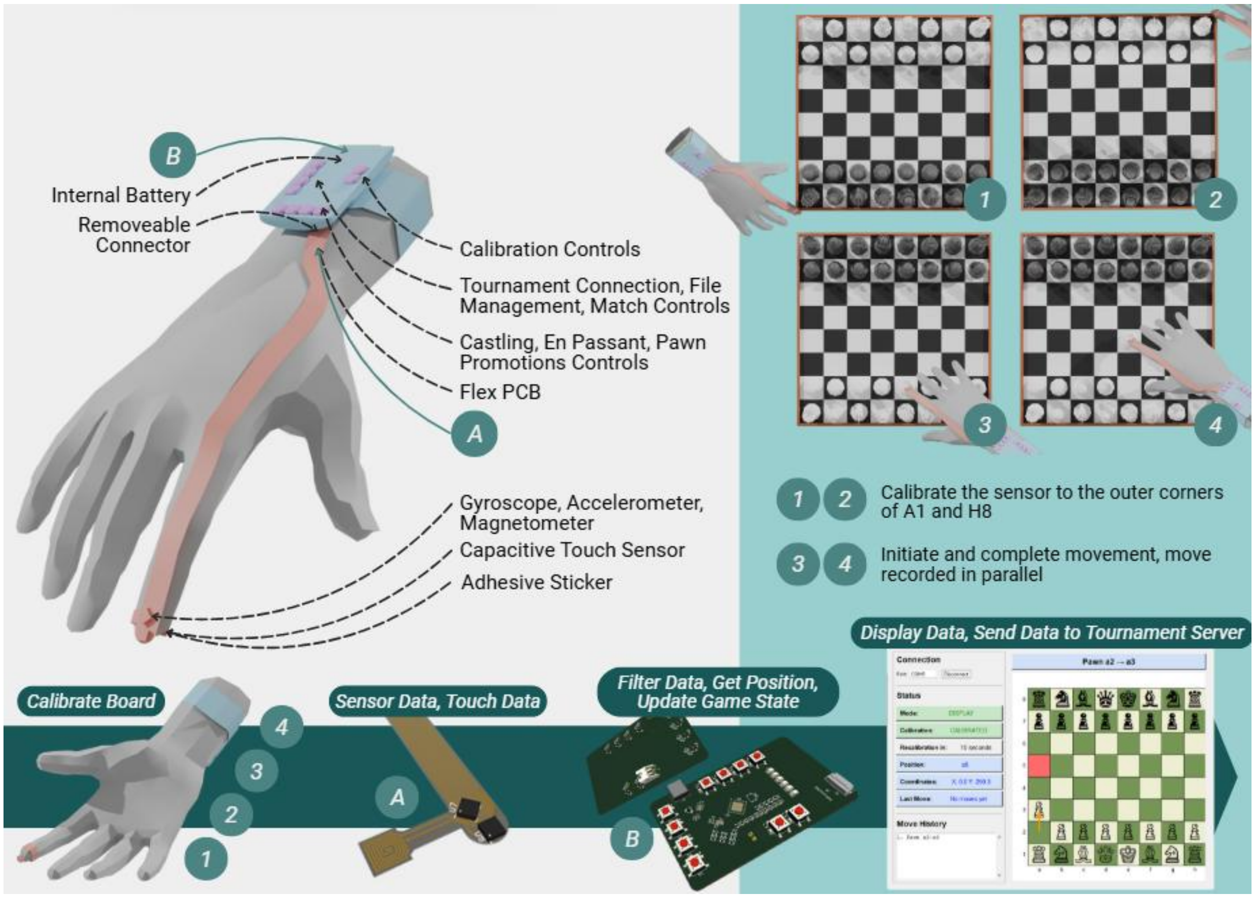


Figure 27: Snipped taken from our final poster design, the top-left shows the complete design, the top-right shows the way in which the design is calibrated, the arrow on the bottom shows the overall technical process through which it works in generality.

After the design was completed scoped out in CAD, PCB schematics, etc. it was then made into a prototype as shown in figure X.

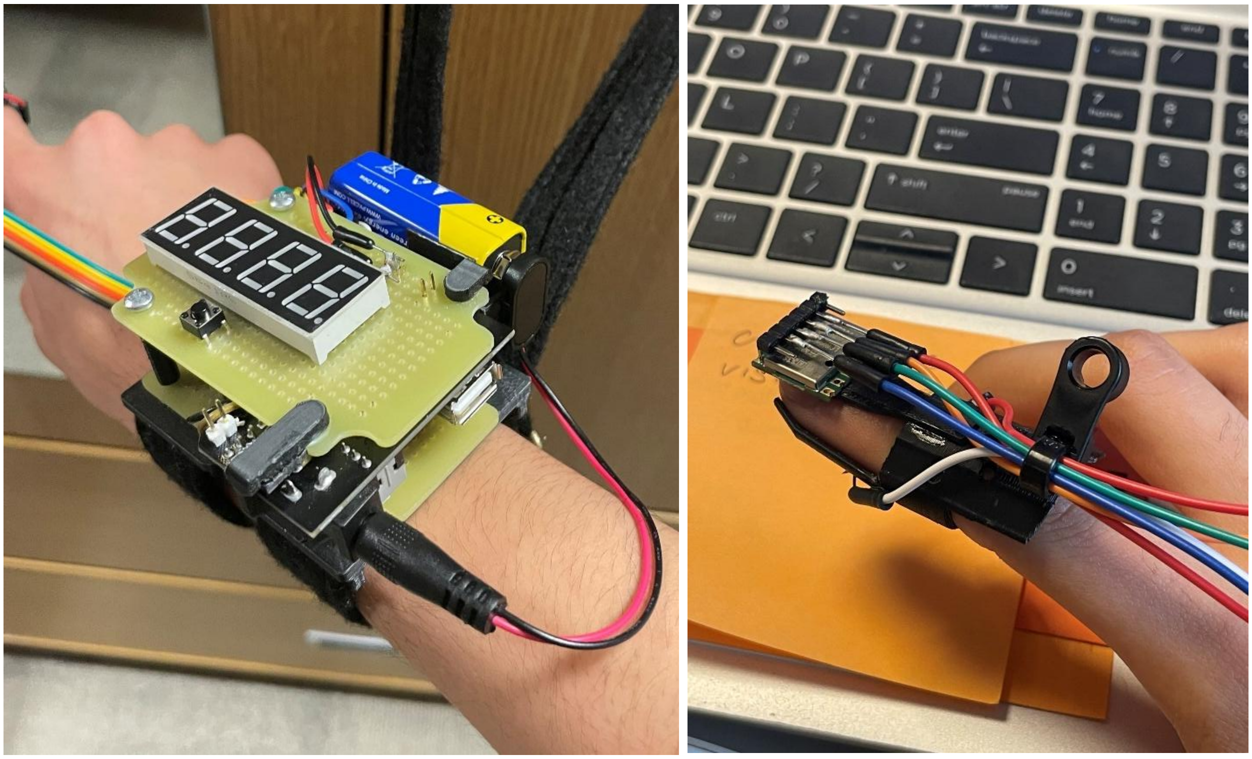


Figure 28: Left depicts the main MCU, battery, and screen module, the right is the simulated use of the flex-PCB where a push button is used and a 3D-printed chassis instead of it.

After the prototype was complete we went to Hart-House chess club to validate our prototype as shown in figure X by asking chess players a set of questions as discussed in the following sections.

Figure 29: Testing out TACTI and asking chess players questions regarding their experience with TACTI, faces redacted for privacy.

5.3 CTMF 1 – The Power of Unrelated Discussions and the use of Random Word

5.3.1 Definition of Random Word

Random words are a diverging tool whereby we would choose any random word and take that forward to develop a set of design ideas. [8]

5.3.2 Definition of Psychological Safety and Team Norms

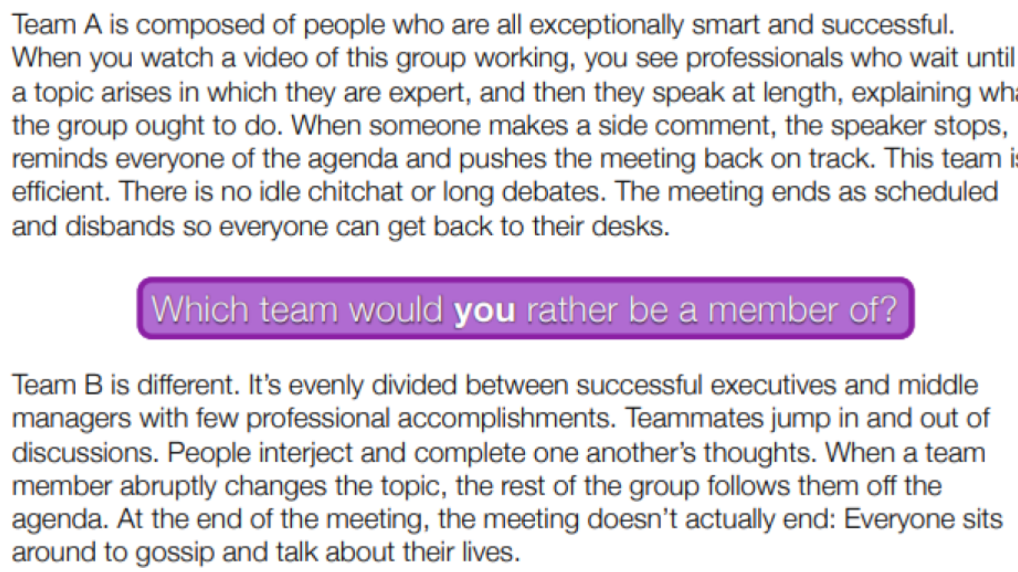
Psychological safety is the establishment of a set of team norms that are conducive to produce discussions and that allow for the finding of common ground in terms of values, perspectives which ensures that effective decision-making is able to be done. [8]

5.3.3 Usage Unrelated Discussions and Random Word

Whilst we did use Random Word in our diverging process, it is my opinion that the use of Random Word was not noteworthy. Rather the conversations that we had that were not even tangentially related to our work in Praxis II were incredibly vital for the extremely wide range of designs that we had come up with, effectively allowing us to explore the entire design space. I can say that we explored the entire design space as there were designs that were very farfetched such as the EEG (electroencephalogram) in figure 24 design f2.

The use of Random Word came about only because of a previous discussion about the use of Chiffon and Brocade Fabrics by *RvH* resulted in us using the word Chiffon in the random word exercise and resulted in use getting the whole “lineage” or category of designs that would be sensor matrix related as shown in figure 24, design c1 to c3.

These discussions were only possible through the early establishment of a set of team norms that were conducive to psychological safety so that team members were able to talk in a more casual matter, such as things that were not related to our work as a team. I believe that this is further supported by the team A vs. team B dynamic given in figure 30 and that a team that is flexible and that can act as both teams is the most effective.


Team A is composed of people who are all exceptionally smart and successful. When you watch a video of this group working, you see professionals who wait until a topic arises in which they are expert, and then they speak at length, explaining wha the group ought to do. When someone makes a side comment, the speaker stops, reminds everyone of the agenda and pushes the meeting back on track. This team is efficient. There is no idle chitchat or long debates. The meeting ends as scheduled and disbands so everyone can get back to their desks.

Which team would **you** rather be a member of?

Team B is different. It's evenly divided between successful executives and middle managers with few professional accomplishments. Teammates jump in and out of discussions. People interject and complete one another's thoughts. When a team member abruptly changes the topic, the rest of the group follows them off the agenda. At the end of the meeting, the meeting doesn't actually end: Everyone sits around to gossip and talk about their lives.

Figure 30: Teamwork dynamics as taken from source. [7]

I personally resonate with this phenomenon as I have also observed firsthand for inspiration to come from the most unexpected places as given in section 2.3.3.3.

5.3.4 Key Takeaways of Unrelated Discussions

1. Having unrelated discussions can be considered productive at times especially if these discussions allows one to get closer to team members getting to know them better (by way of hobbies, interests, etc.). This has the added benefit of allowing team members to more quickly find common ground in future disagreements and solve them equitably.

2. The discussion of supposed "unrelated" ideas is important as that is what the guiding principle of Random Word is – we use a random world unrelated to the design or task at hand to try to gain inspiration to solve it. Random discussions are a vital part of this process.

5.3.5 Shortcomings of Unrelated Discussions and Random Word

1. It is careful to note, however, that excessive discussion of things not related to work is generally not ideal as time might be wasted on things that does not get project deliverables done. It is best to structure unrelated discussions during down-time, especially during group-work sessions, where discussions such as these can prove to be a useful break from work.

2. It is also pertinent to concede that this effect is not always possible and that it is up to chance that any given discussions are able to used in the Random Word process in the future, it is however a given that discussions such as these are able to bring the team together and increase work efficiency and so there remains a benefit to unrelated discussions.

5.4 CTMF 2 – The Curb Cutting Effect

5.4.1 Definition of Curb Cutting Effect

The Curb-Cutting Effect refers to the phenomenon where a design change or innovation initially intended to benefit a specific group ends up providing broader advantages to a much larger population. In the example given in Praxis II, curbs cuts were initially made to help those in wheelchairs but later had the benefit of helping cyclists, workers with dollies and carts, those with impaired vision, etc. [X]

5.4.2 Usage of the Curb Cutting Effect

When visiting Hart House chess club to complete our final validation of the prototype with our stakeholders, one of our stakeholders mentioned that they found the device useful enough to use even outside of applications such as a damaged dominant hand.

Since the device records moves as they are made (in parallel) rather than after such as with a pen and paper (where you make the move and then write it in series), it would completely remove the need to take focus of the chess game. We found that upon refining our question set to also ask casual players if they would be more willing to take part in tournaments if they didn't have to memorize the FIDE chess algebraic notation that these casual players would be more than willing to take part in the game.

We noted that if this device was able to reduce the barrier of entry to chess tournaments and chess overall it might make chess more popular and allow hidden talent to come out, thereby leveling the playing field for those who are not fortunate enough to be able to train for hours a day outside of other commitments.

This curb cutting phenomenon has proven to be incredibly important to my goal as an engineer as it allows my solutions to be able to improve the lives of those around me a more far reaching way than initially expected.

5.4.3 Key Takeaways of the Curb of the Cutting Effect

1. Curb cutting is an important phenomenon as it allows solutions to have a wider reach and be able to improve the lives of a greater number of people – this improvement directly impacts the human condition and can be considered a great asset in the goal of achieving social impact with engineering.

5.4.4 Shortcoming of the Curb Cutting Effect

1. It is important to note that one should be careful when assigning a "solution" to a given group of people, groups of people can have very specific needs than cannot be met with a "one-size-fits-all" solution and make become alienated at the prospect of just becoming another number. It is important to take the lived experience and crucial perspectives of these communities to ensure that real value is realized for them.

5.5 CTMF 3 – Analysis and the Importance of Low-Level Scoping

5.5.1 Definition of Analysis

Analysis [7] in terms of Praxis is the use of some sort of computational simulation tool to verify whether a design meets a set of a requirements and thereby realizes genuine value for the stakeholders and community at hand. [7]

5.5.2 Usage of Analysis

In Praxis II we had decided to scope out all the low-level design features of all proposed solutions on figure 24 as it would allow us to do a sort of "pseudo-attribute listing" and thereby find ways of reducing complexity in the final design by way of combining of truncation features completely from the design. As shown in figures 22 and 23 (and appendix 7.1), I completed medium-fidelity CAD models, PCB schematics, and ran schematic analysis. Retrospectively, as a side effect, by doing this type of low-level scoping I was able to run the necessary electronic schematic analysis to determine theoretical energetic analysis and determine how long the device would be able to run on a 9-volt battery, thereby allowing us to proxy test our critical requirement of operating time.

This type of scoping out allowed for the removal of some complexity and the outright cancelation of the computer vision strain of designs as it was deemed to technically complex for the task at hand, given its susceptibility to differing light levels, board and piece colors, angles, etc.

5.5.3 Key Takeaways of Analysis

1. I believe that the usage of analysis is closely related to my position the sense that to achieve any meaningful use of analysis a low-level scoping of the design must be completed, this thus ensures that real value is provided to the stakeholder and thereby it means that the greatest possible positive social impact is achieved.

2. It is essential to reduce complexity to ensure that genuine value is realized as the more complex a solution is the less likely it is to be adopted. By ensuring that the low-level design was scoped out in completion, I maintained a strong awareness of the phenomenon where the actual complexity of a given design is often downplayed in high-level discussions. This approach has allowed me to accurately represent complexity and maintain the highest possible level of value for our stakeholders.

3. I believe that this in-depth design work at this level is rare, and should be more commonplace as it has an effect that is two-fold: first, it allows one to develop and hone the necessary technical soft skills such as CAD, PCB design, and CFD required for more technically complex projects; and secondly it allows one to combine features and remove them as needed to ensure that the final design complexity is reduced.

5.5.4 Shortcomings of Analysis

For both below shortcomings of analysis, it should be noted that both are due to time constraints rather than any intrinsic issue with the low-level design and then analysis, these are able to be mitigated with careful planning, skill, or by using it only when strictly necessary such as when a new type of technology is being scoped out.

1. It can be argued that the most major shortcoming of completely scoping out all designs in the design space is the time-consuming nature of such a process – time that could instead be used to scope out further high-level designs rather than this low-level scoping

2. It can be further argued that the usage of analysis as a method of validation should only be done in the case when there is no low-fidelity prototyping available and therefore there is no chance of doing any proxy-testing as the time spent on analysis could be time saved in this way.

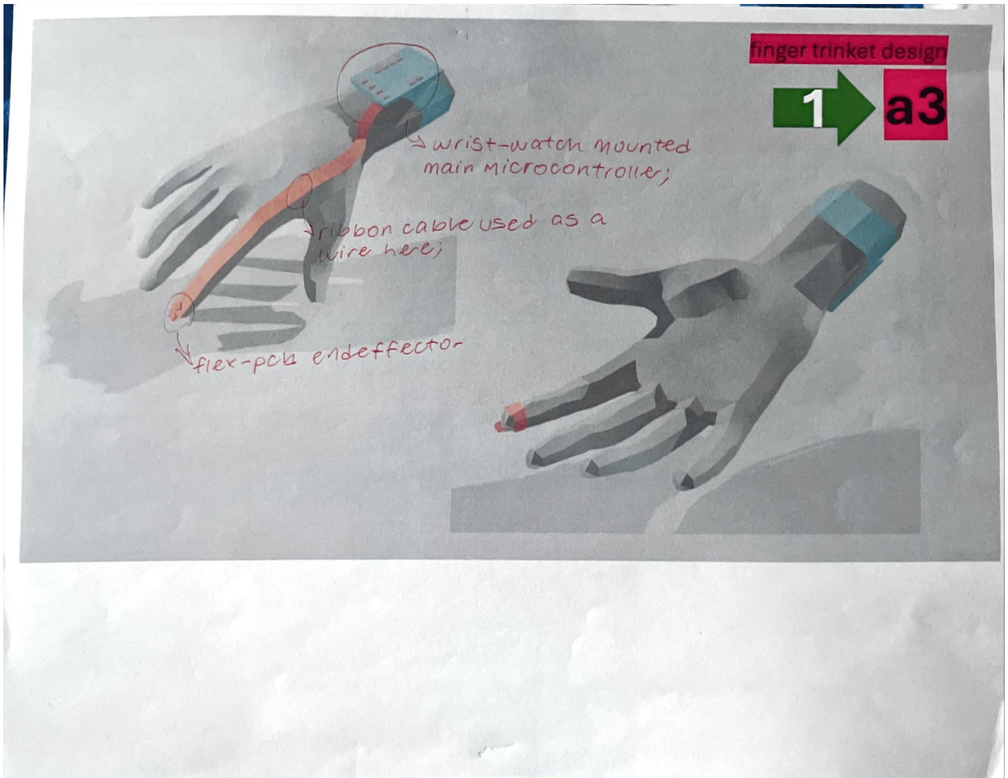
6.0 Conclusion

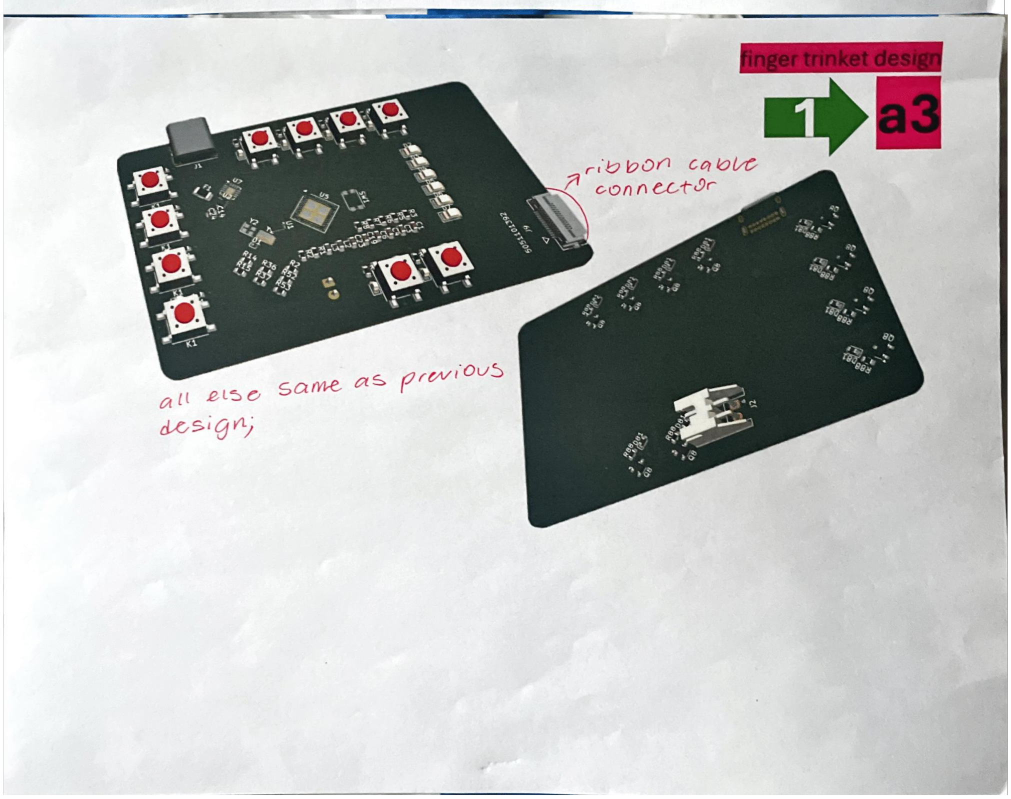
While my engineering design process will undoubtedly evolve throughout my career, my guiding principle remains constant: engineering must serve a purpose beyond technical achievement—it must create positive social impact.

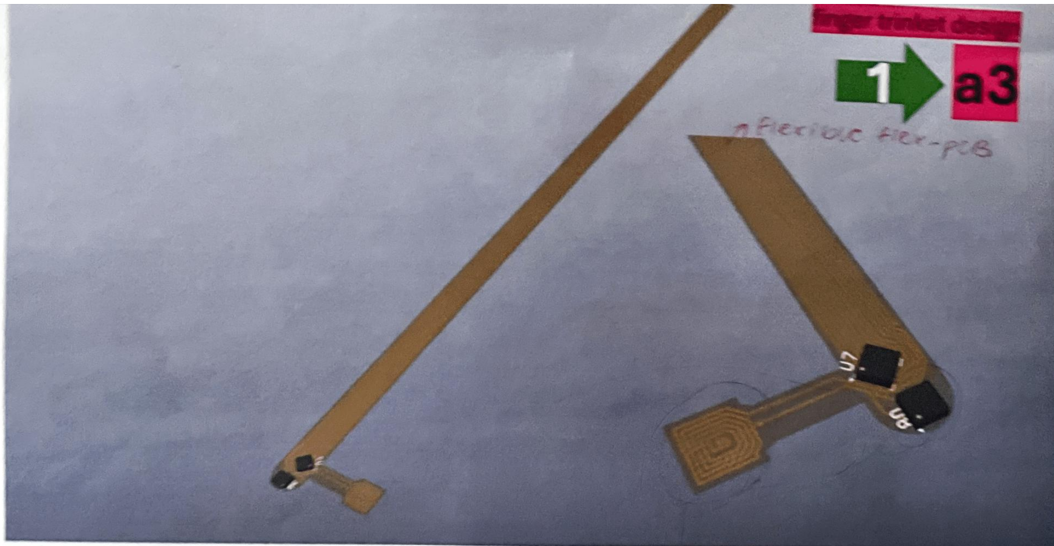
This perspective frames how I select problems, approach solutions, and evaluate success. In my view, there is no field with greater potential for positive change than engineering. After all, what is the purpose of an engineer if not for the people?

7.0 Appendices

7.1 Beta Designs in Detail



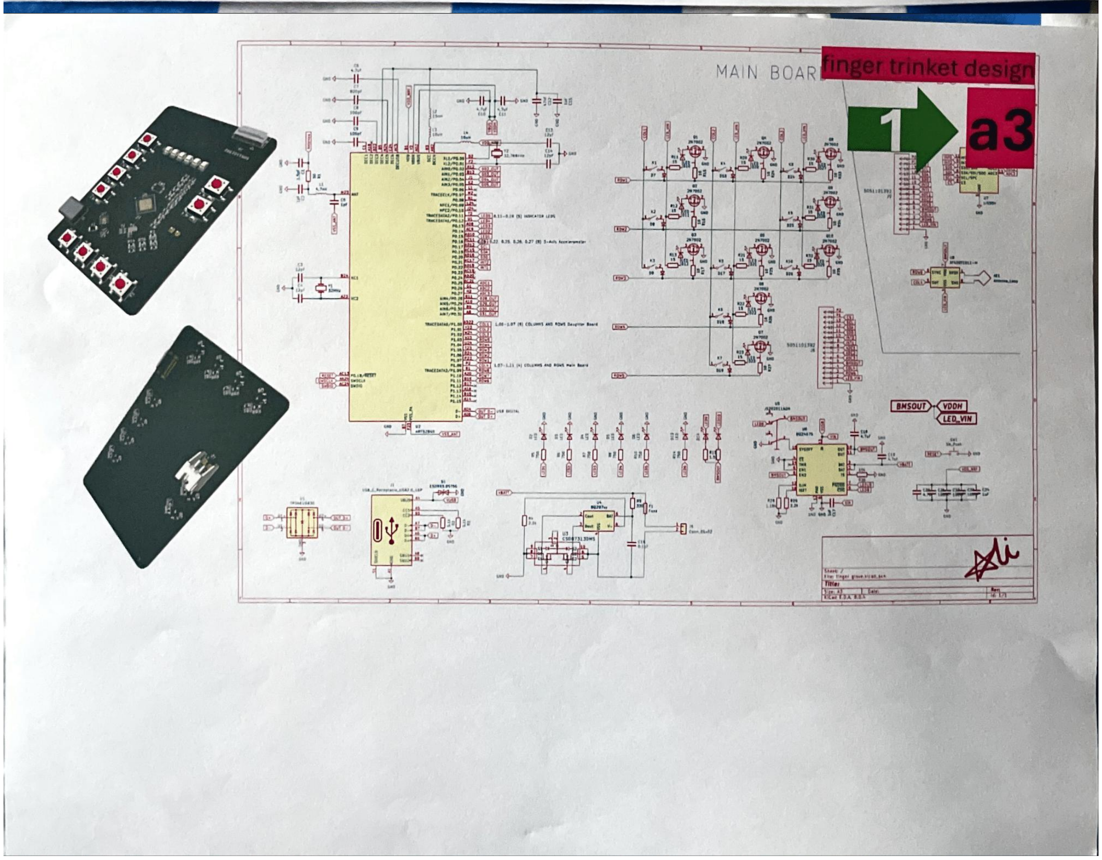


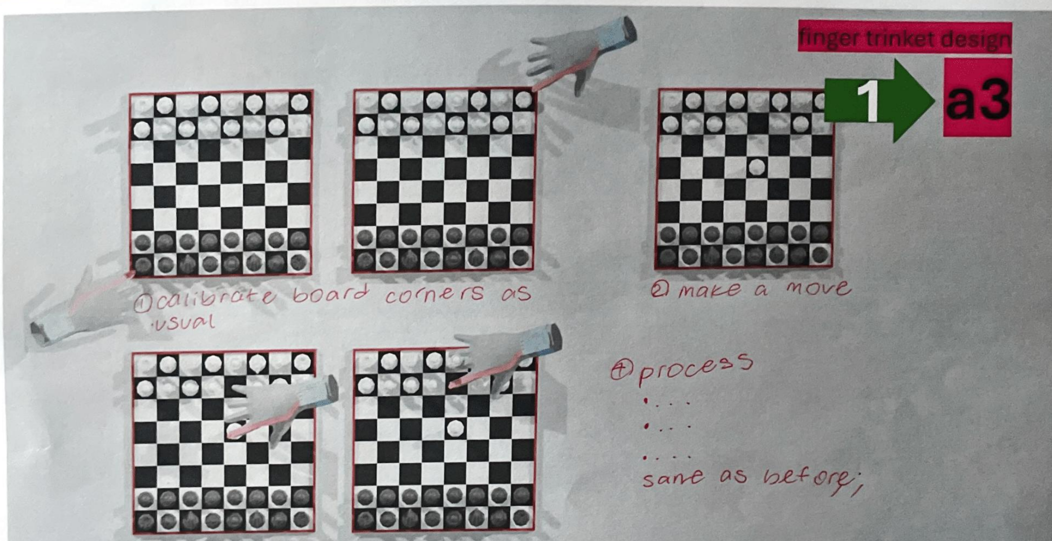


3-axis accelero-mete.

capacitive touch drive

capacitive sensing array coil;
contains a sticky-note type adesive for sticking to index finger;

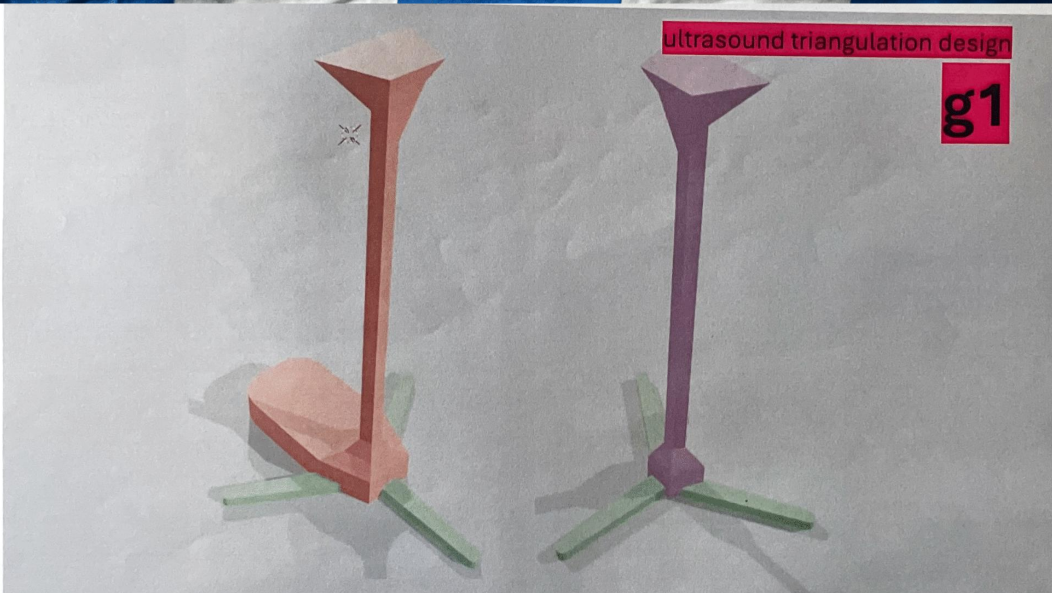




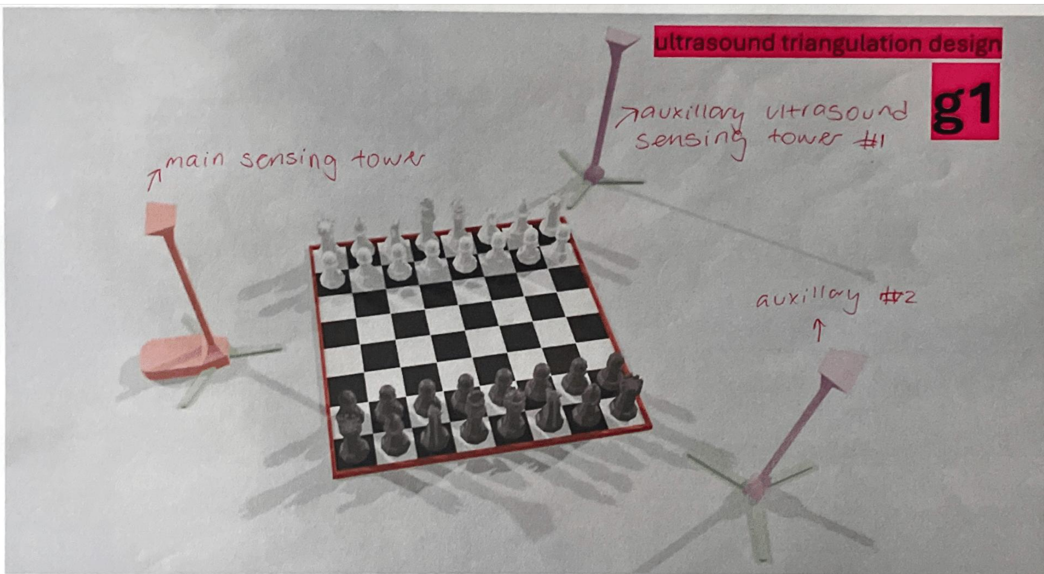
⑤ during the move, when you grab a piece in the next clock cycle (<1μs) the position is noted of the unkown piece

③ when you let you, in the next clock cycle the ~~next move~~ end position and this square is found;

③ piece type is known from start position as all chess games start from a standard pattern;



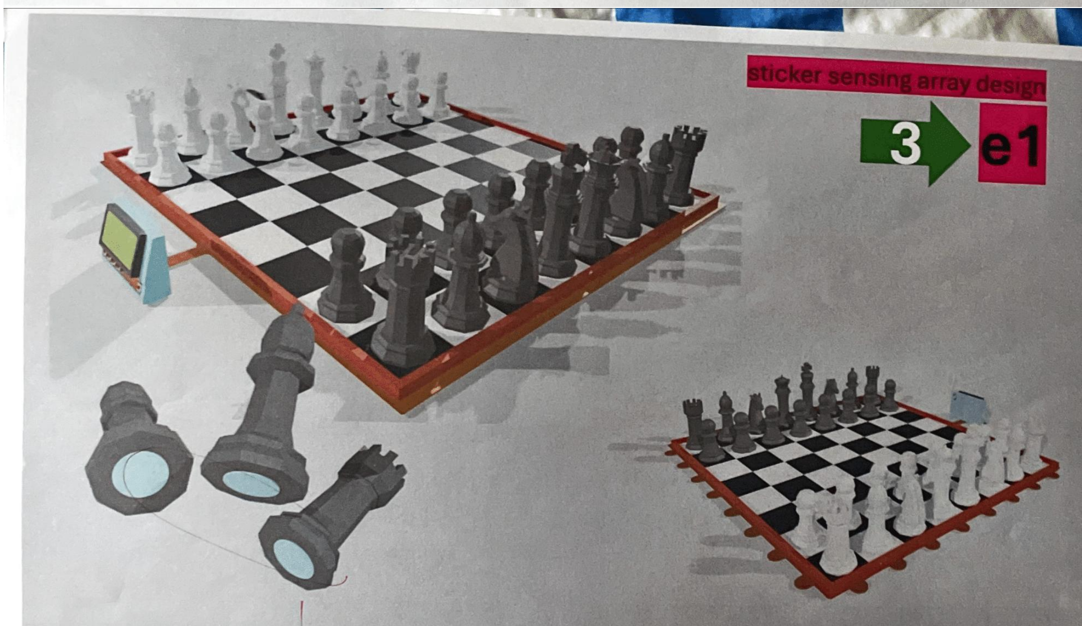
Voided By FIDE REQUIREMENT
technical Reccomendation for tournaments
1.2.2



*devices emit ultrasound

① time taken × speed of ultrasound = distance

② triangulation of all pieces is achieved by using the three sensors;

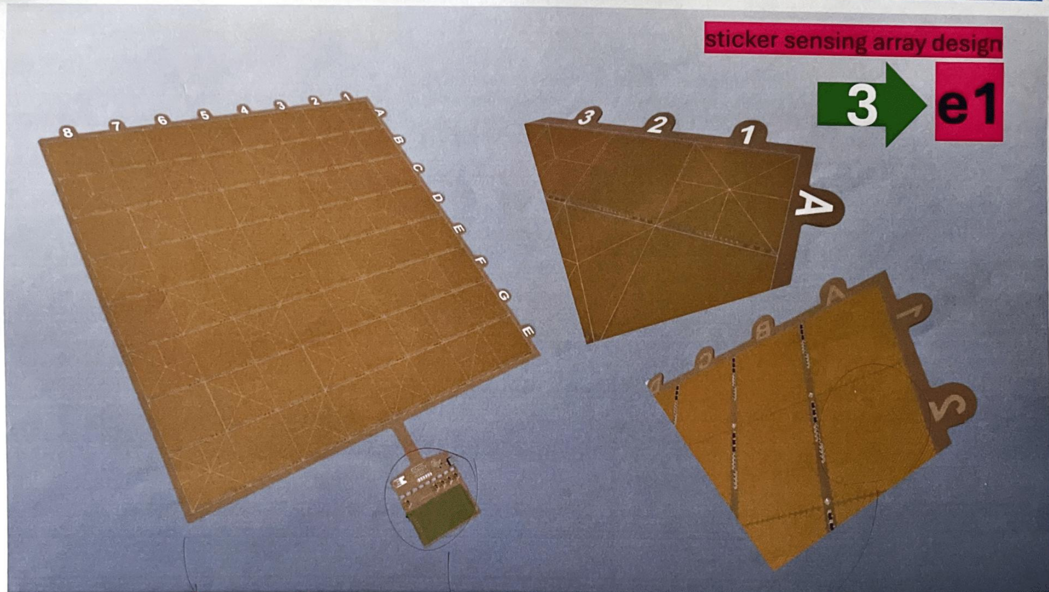


all pieces have the same magnetic pad as:

① large copper coils means that we can detect small changes in magnet fields, once a piece is moved a magnet flux change takes place and charge is induced in the pads

② this allows the location of pieces to be found

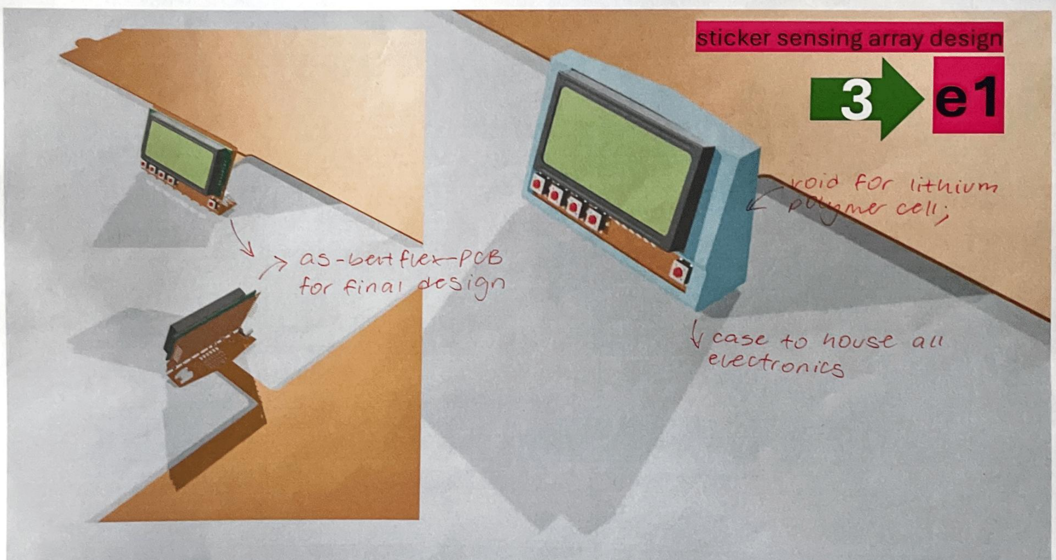
③ the board starts with standard arrangement and so pieces types are known;

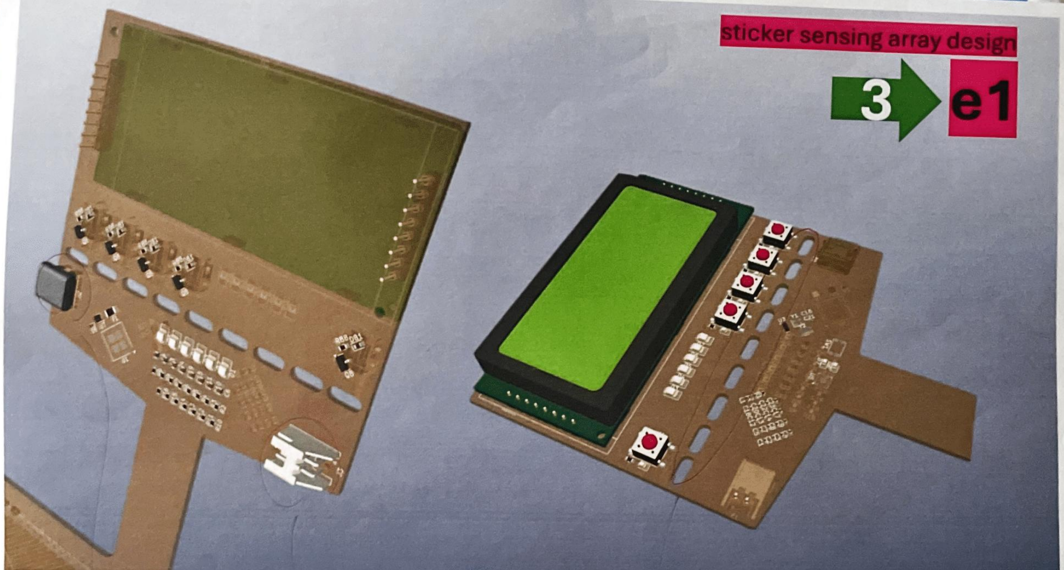


large flex pcb

control board ~~ba~~ daughter-board

large copper-trace pads;



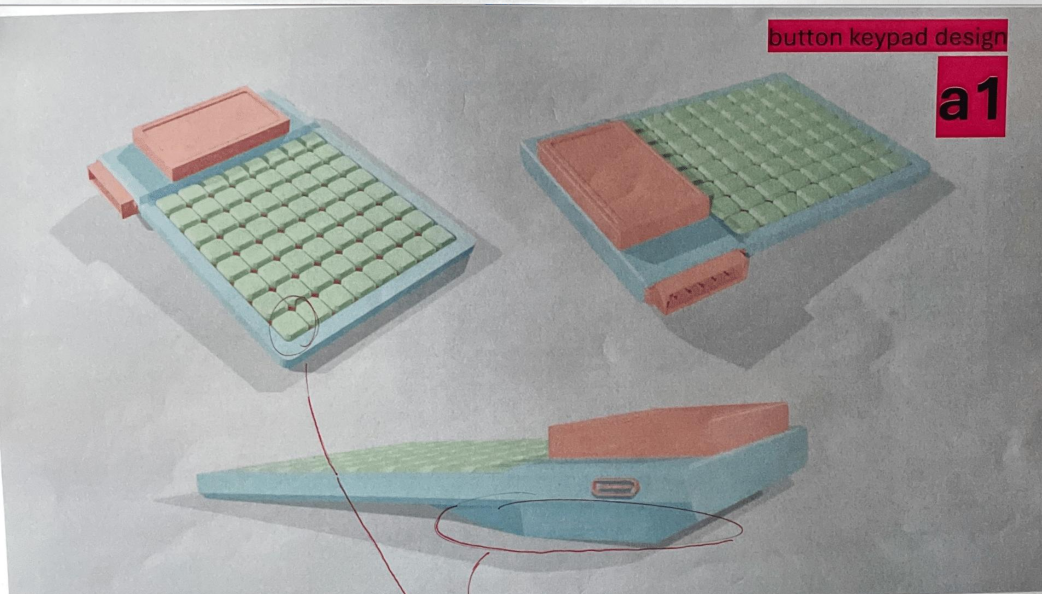


lithium polymer control cable

usb c for: same as before
① ...
② ...
③ ...

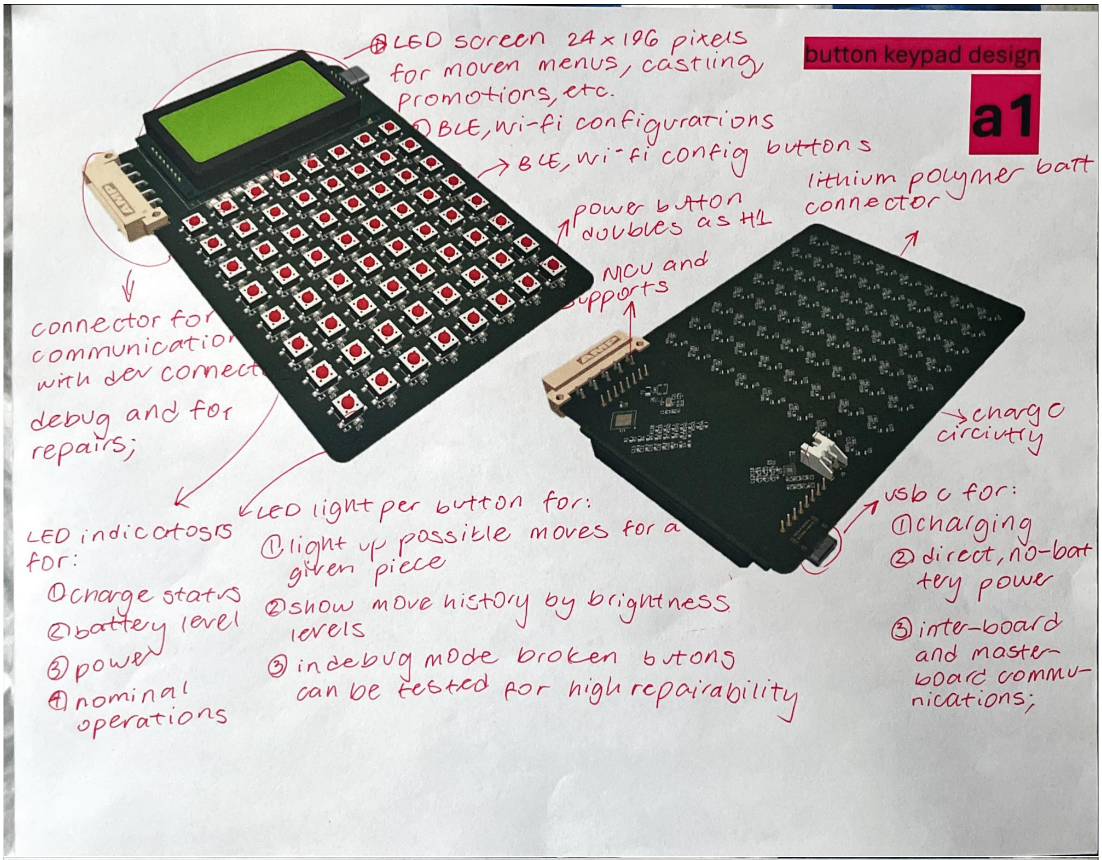
* relif holes for making PCB folding easier

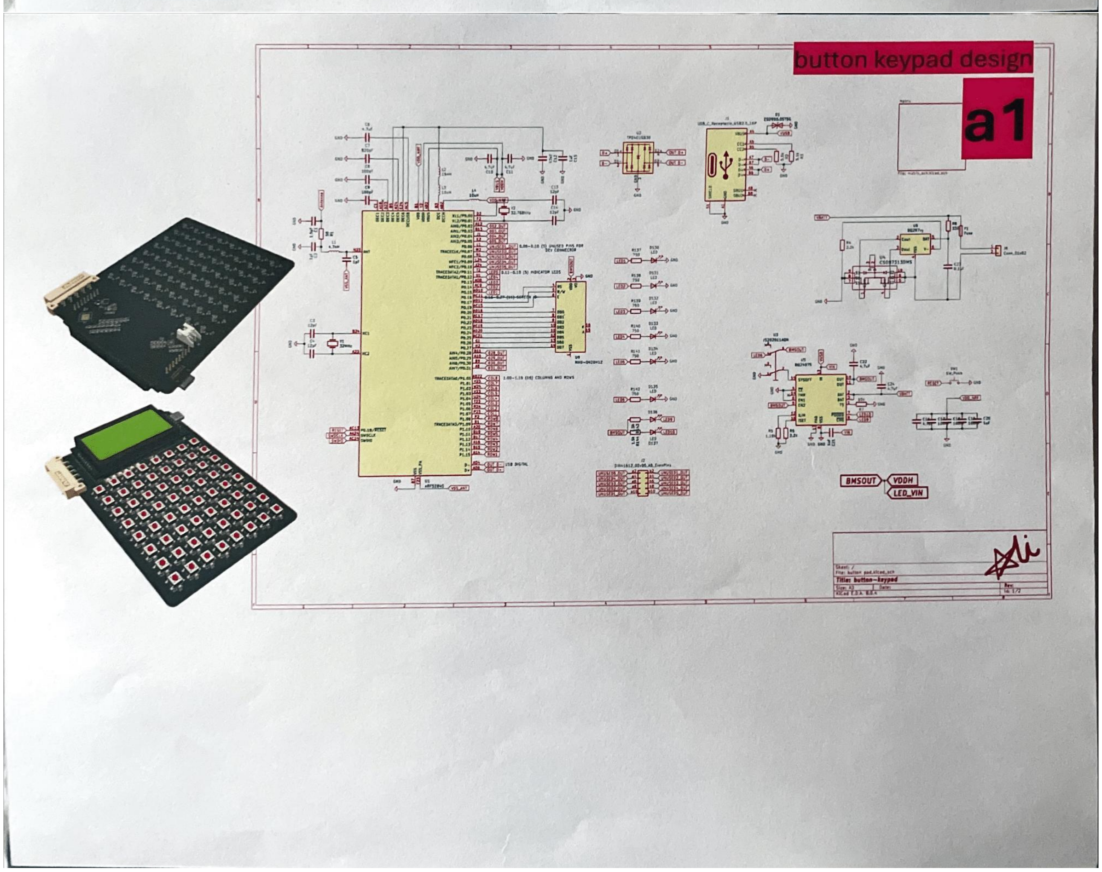
* electronics follow similar architecture to the main control boards as before;

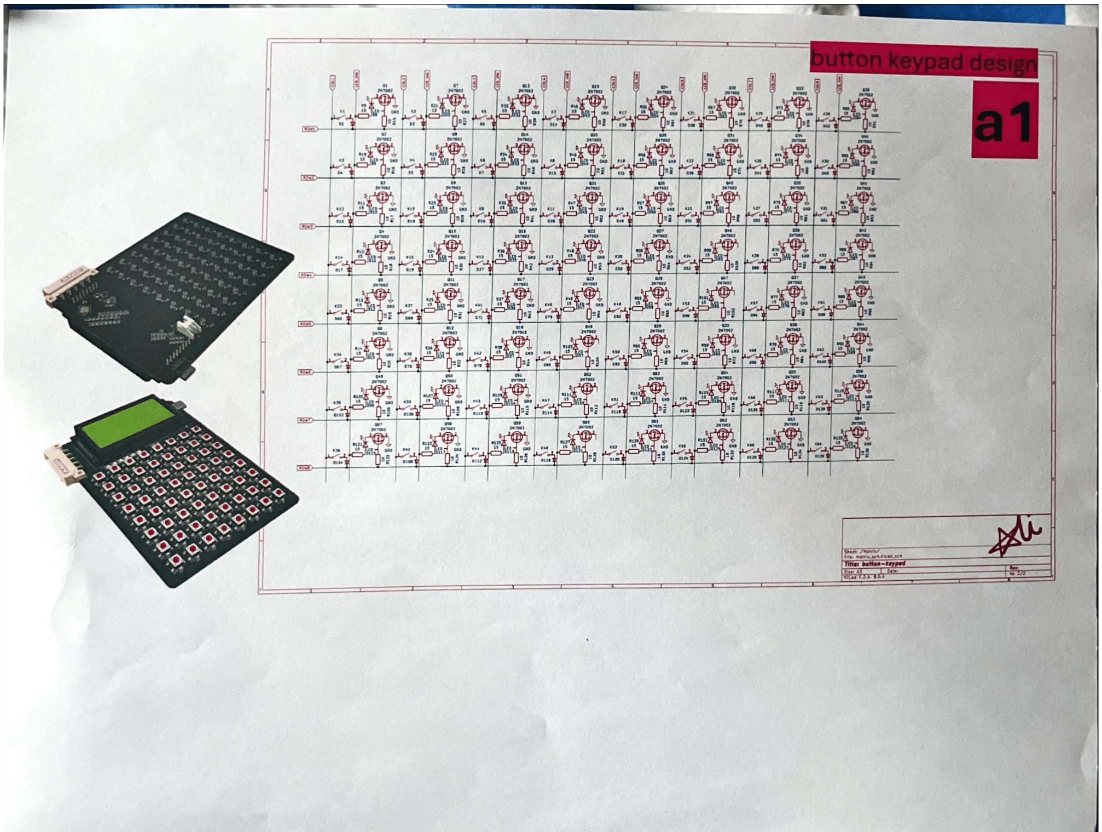


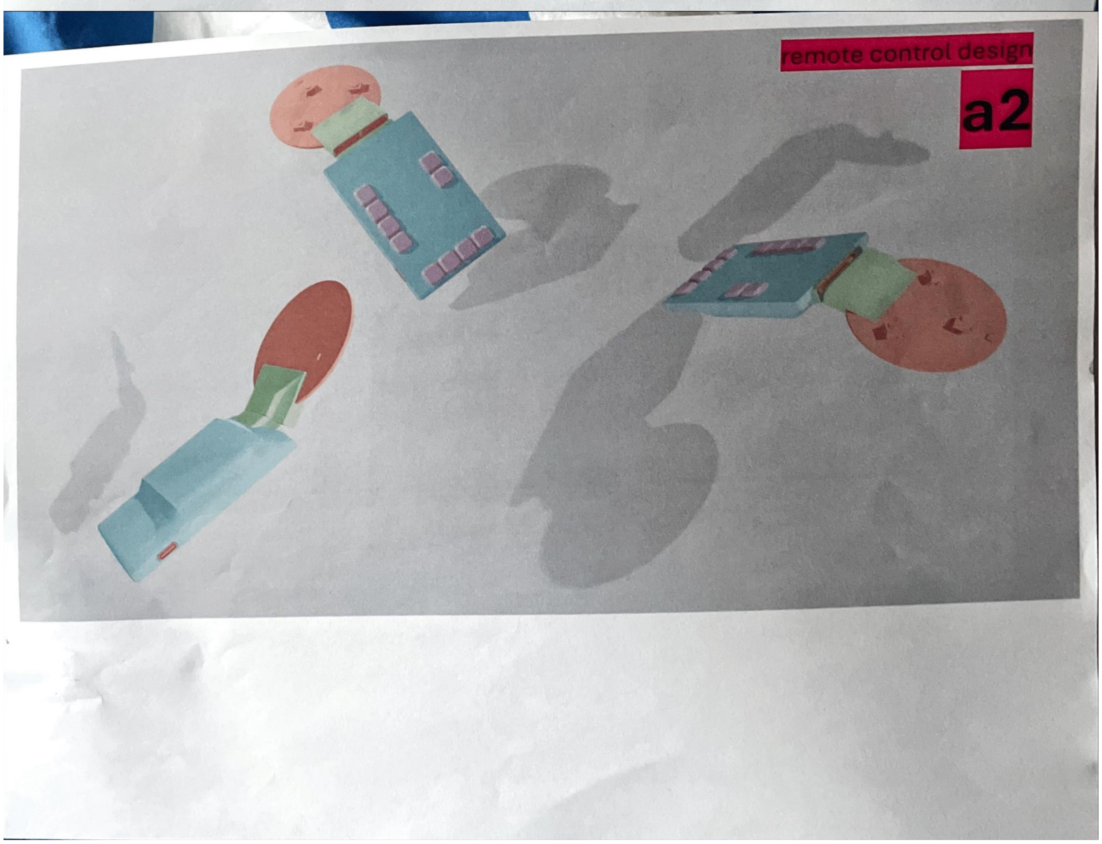
void for flat-pack lithium polymer battery pack;

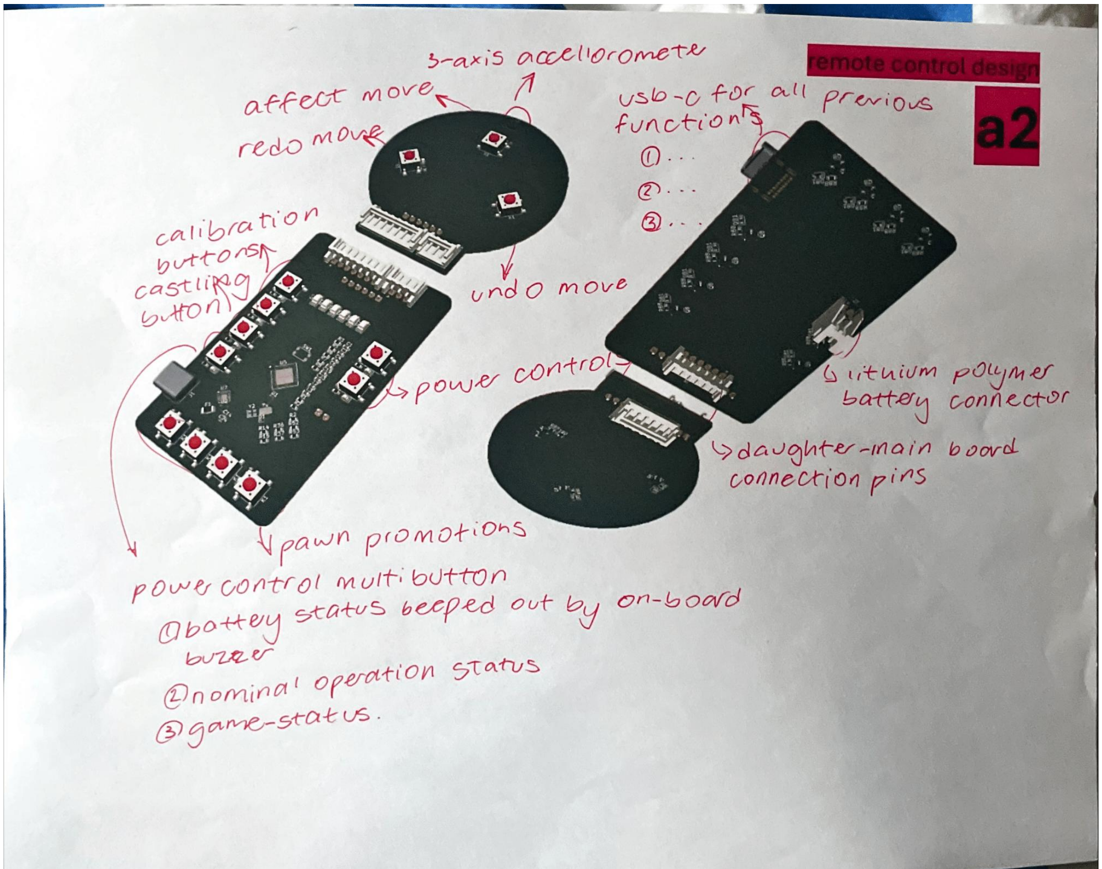
keycaps to reduce the accuracy needed by the players;

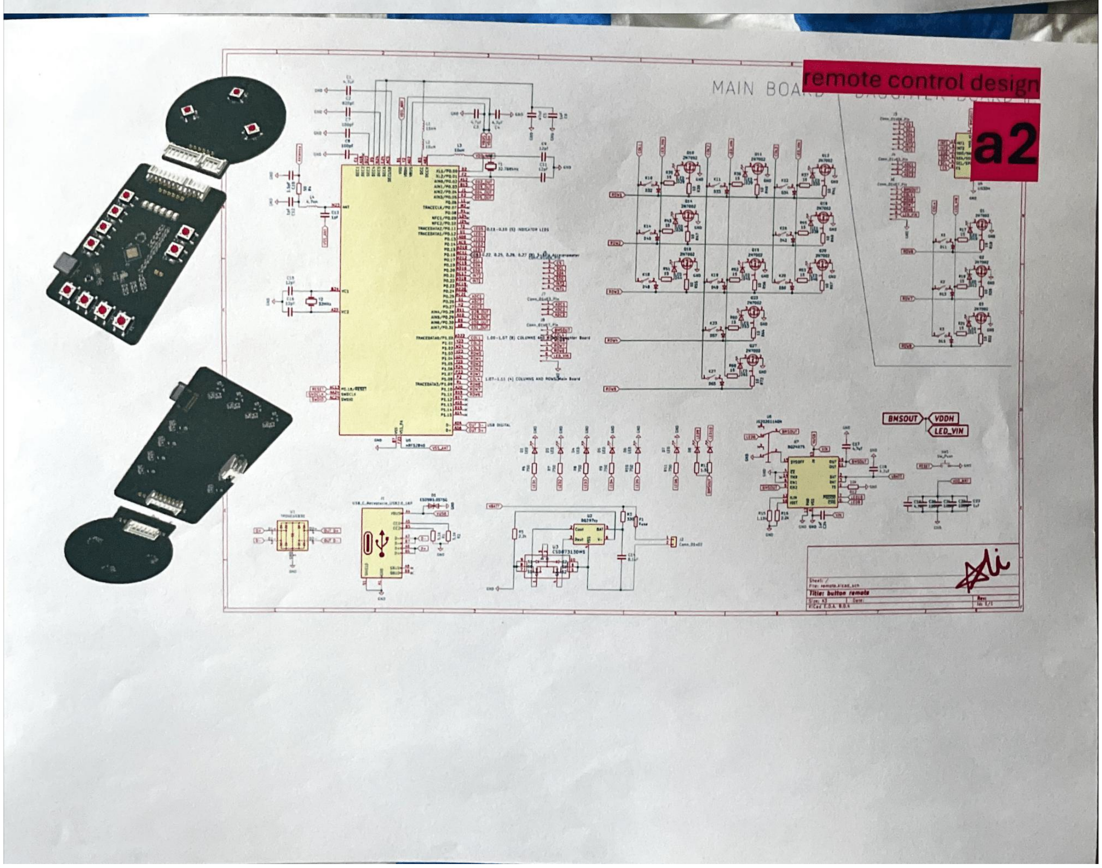

button keypad design
a1
① LED screen 24x196 pixels for moven menus, castling promotions, etc.
② BLE, wi-fi configurations
→ BLE, wi-fi config buttons
lithium polymer batt connector
power button doubles as H1
MCU and supports
connector for communication with dev connect debug and for repairs;
→ charge circuitry
LED indicators for:
① charge status
② battery level
③ power
④ nominal operations
LED light per button for:
① light up possible moves for a given piece
② show move history by brightness levels
③ in debug mode broken butons can be tested for high repairability
usb c for:
① charging
② direct, no-battery power
③ inter-board and master-board communications;


button keypad design
a1
BMSOUT
VDDH
LED_VIN


button keypad design
a1

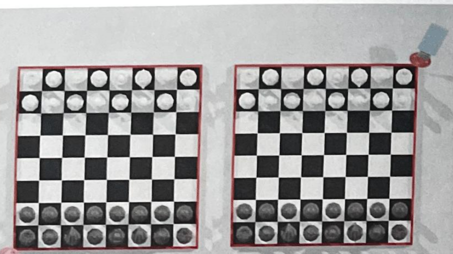

remote control design
a2


remote control design
a2
3-axis acceliorometer
affect move
redo move
usb-c for all previous functions
①...
②...
③...
calibration buttons
castling button
undo move
power control
lithium polymer battery connector
daughter-main board connection pins
pawn promotions
power control multibutton
①battery status beeped out by on-board buzzer
②nominal operation status
③game-status.


remote control design
a2
MAIN BOARD

remote control design

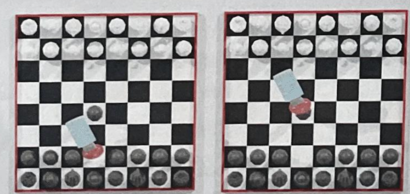
a2



① calibrate the board by using affect move button on corners

② boards are standard by FIDE, thus calibration gives all the ~~no~~ pieces' positions

② make a move;

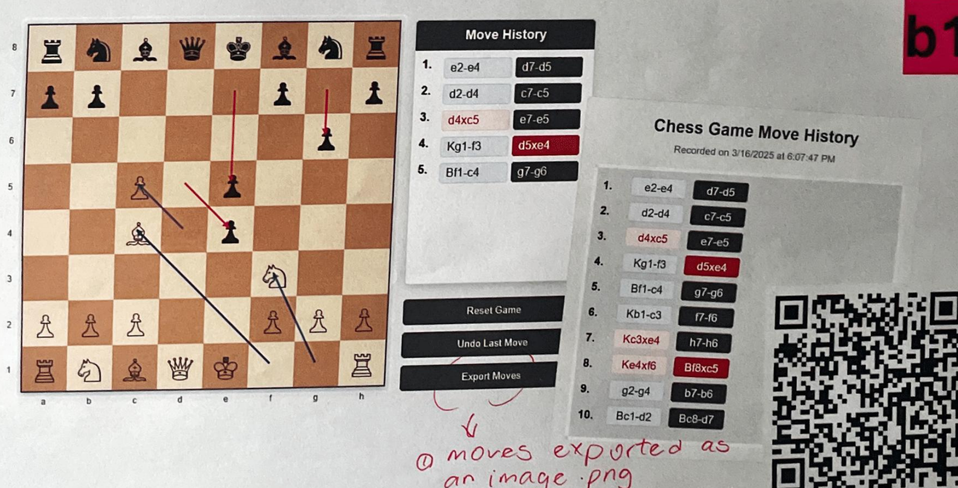


③ click on start move position, click on end move position;

④ process
- accelorometer gives 3-axis acceleration.
- on-board MCU has CPU clock and timing clock
- position is known

phone-based move recorder

b1



① moves exported as an image .png

② or as a PGN file if need be

in reality:

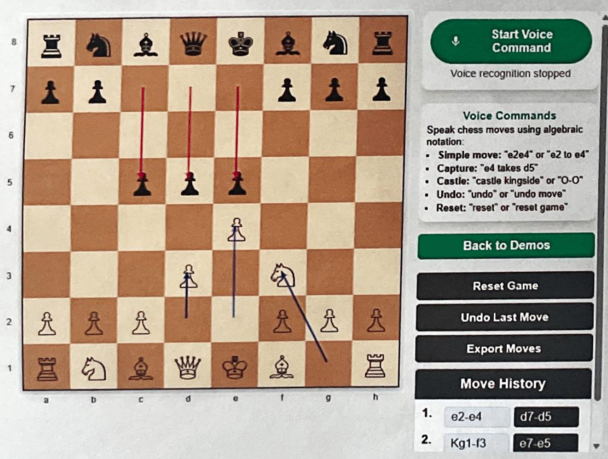
① this would be a phone app not a web-app

② you are only let into the app if airplane mode is on

③ the number of app leaves is logged and the time of leave is logged;

phone-based voice-move recorder

b2

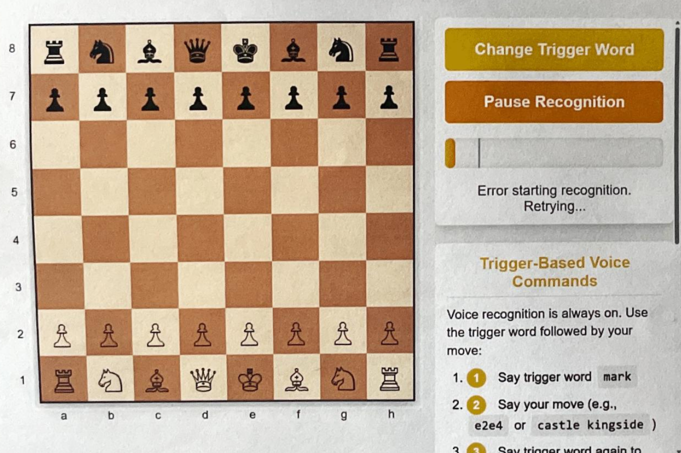


· voice activated moves, for the case of 40dB voice requirement
① whispers as 30-40, 20-30 dB
② for the case of visually-imparied chess players as pe FIDE rules they are able to talk;

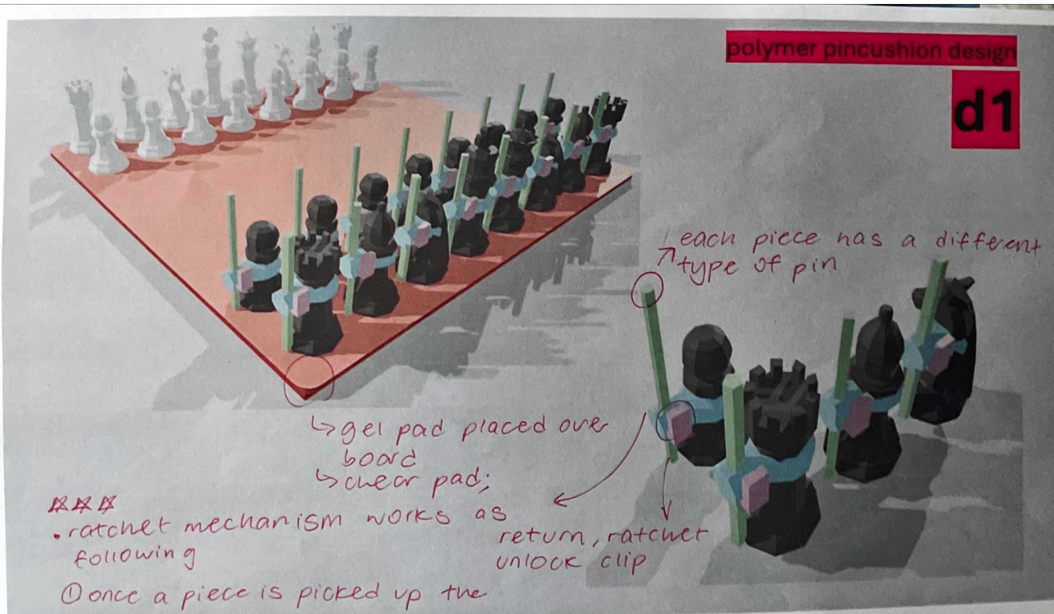
· same intepretation for phone-app conversion;

phone-based trigger-based move recorder

2 b3



the current design always listens,
① once it hears a trigge sound (snap of finges) or a word (mark) it listens for the move and executes once done;
② once the trigger move is set, it only listens for a given sound from a particular peson's accent, innocation, etc;



☆☆☆

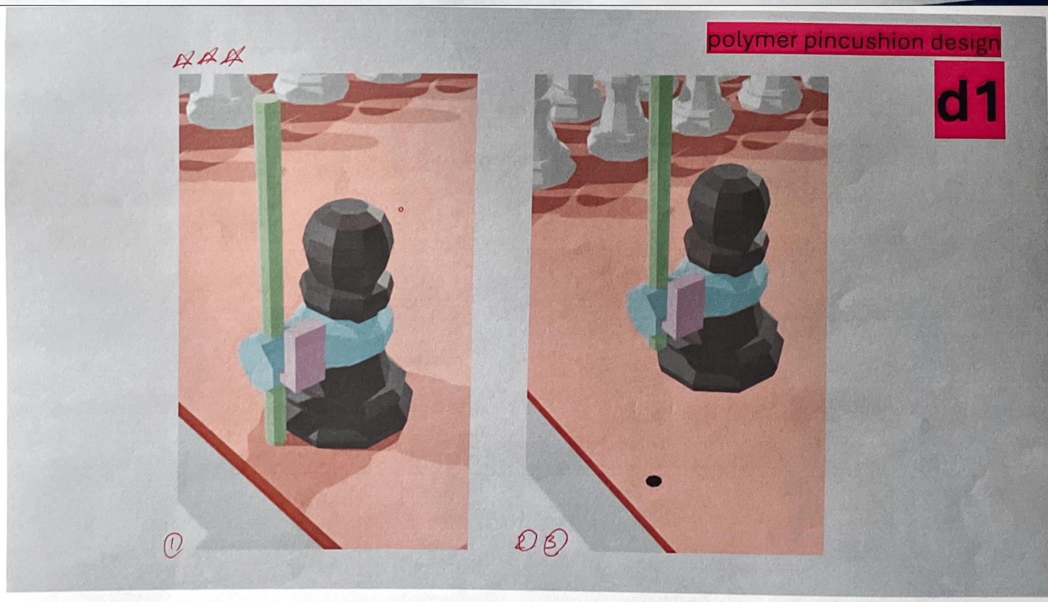
• ratchet mechanism works as following

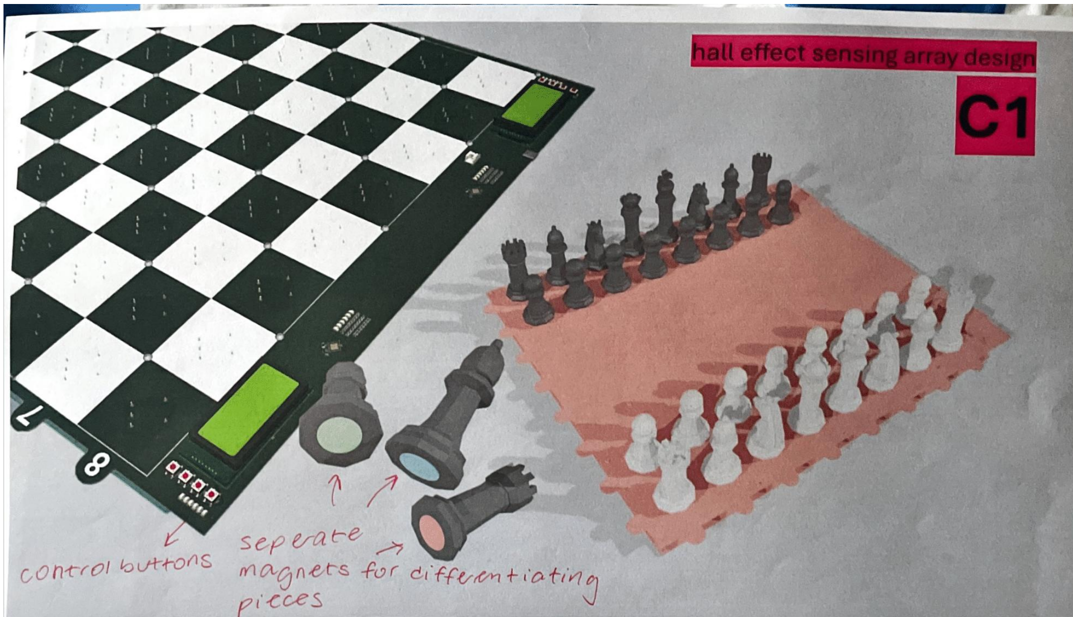
① once a piece is picked up the pin falls down slightly and pushes into the gel pad and leaves an imprint

② positionality of the pieces is given by the type of hole

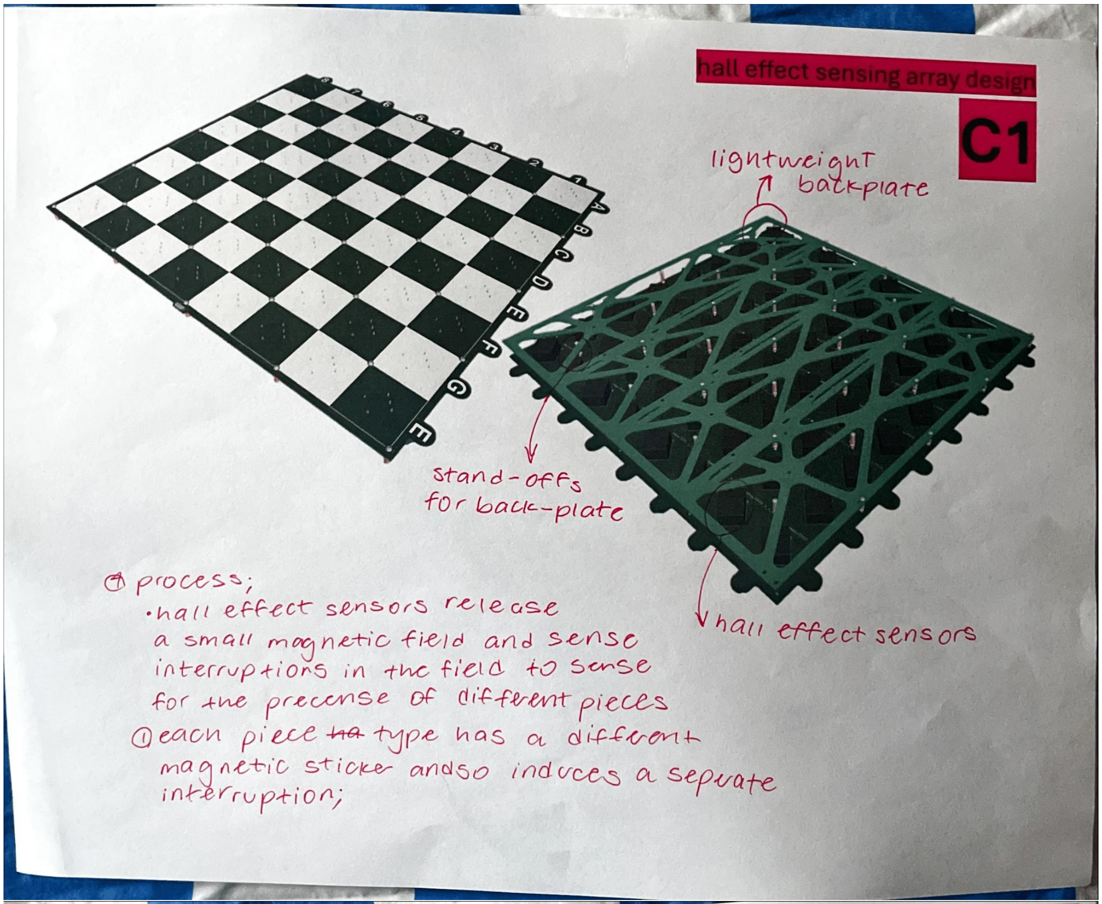
③ depth of the pin gives the temporal axis.

• the gel pad is submitted as a record of all the moves made on the board; this is then scanned and converted to PGN format;

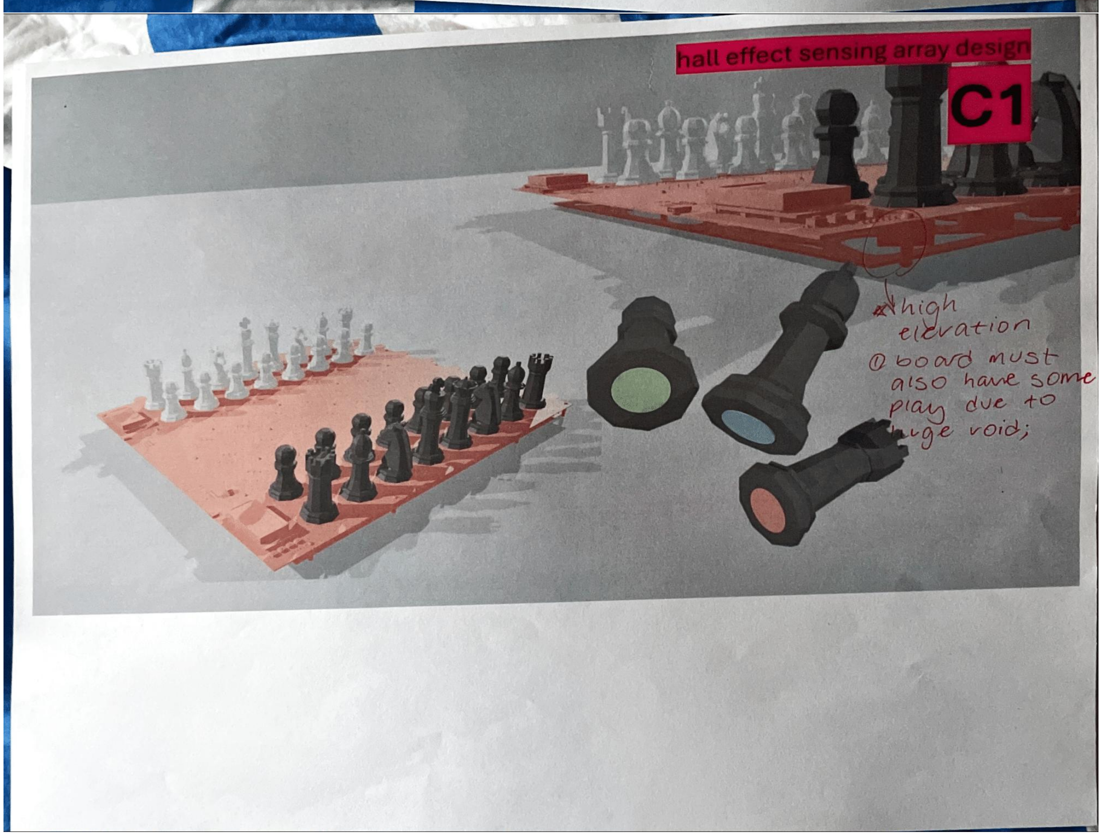




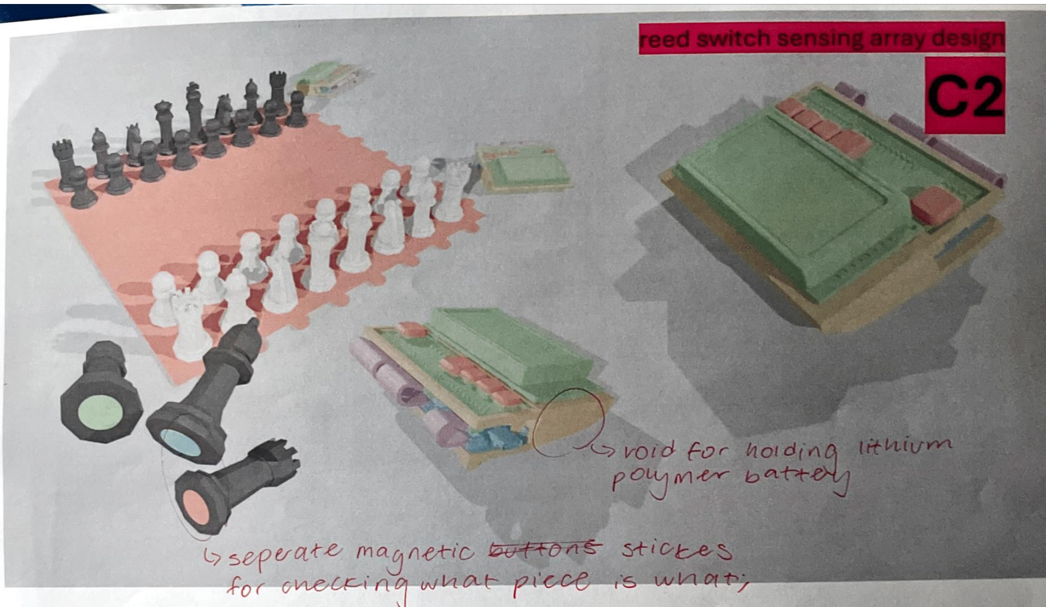
☆ here the two playes have seperate recording systems, they upload sepereately to their own servers

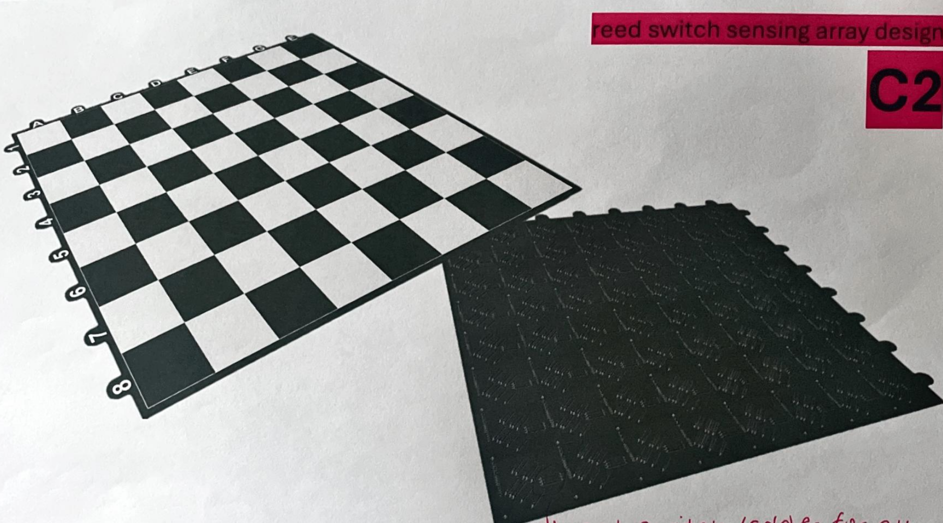


hall effect sensing array design
C1
lightweight backplate
stand-offs for back-plate
hall effect sensors
process;
•hall effect sensors release a small magnetic field and sense interruptions in the field to sense for the precense of different pieces
each piece type has a different magnetic sticker andso induces a sepurate interruption;



hall effect sensing array design
C1
high elevation
board must also have some play due to huge void;





↳ reed switch ladder for all six. possible combinations of all pieces

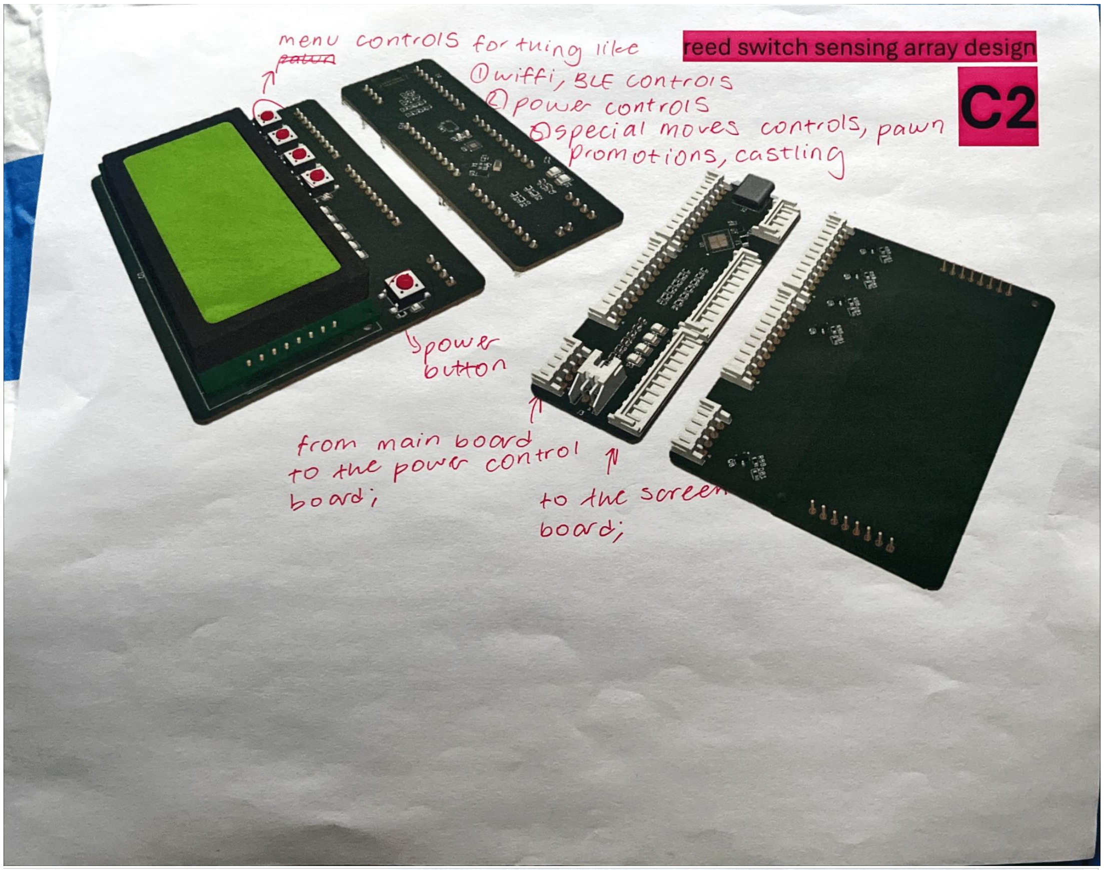
④ process;

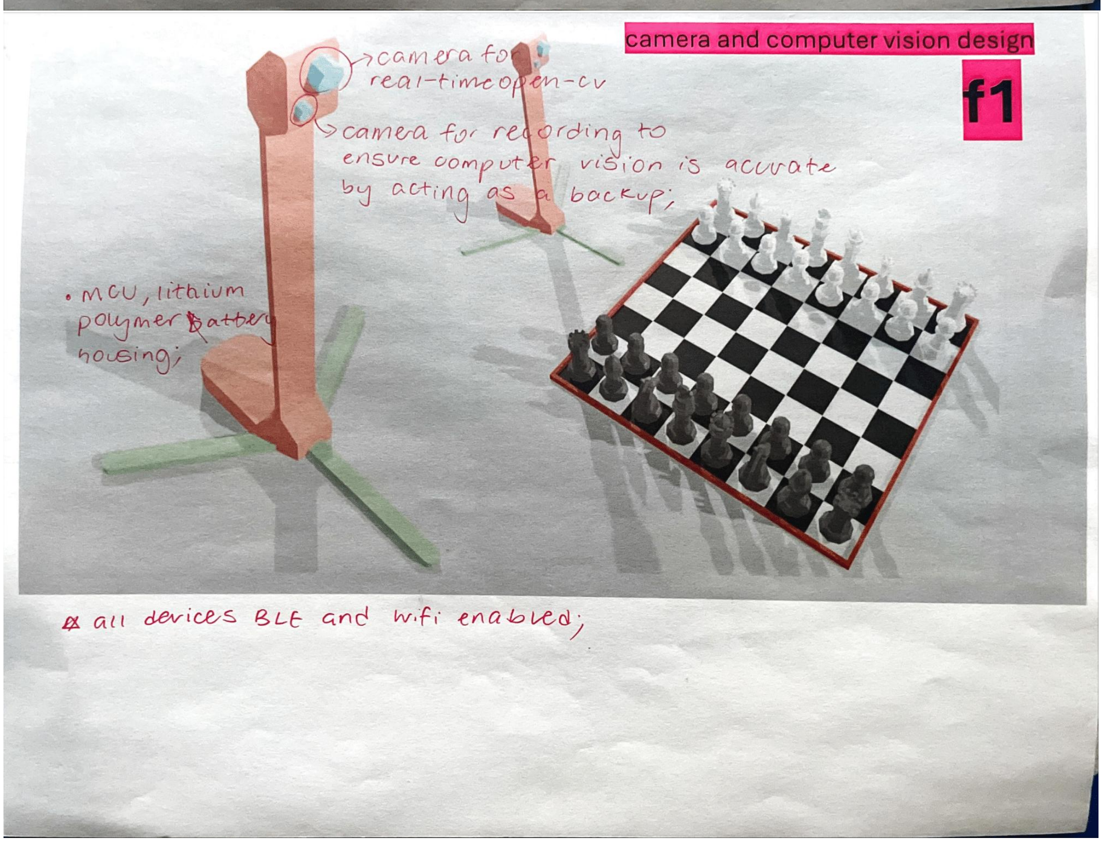
no magnetic field

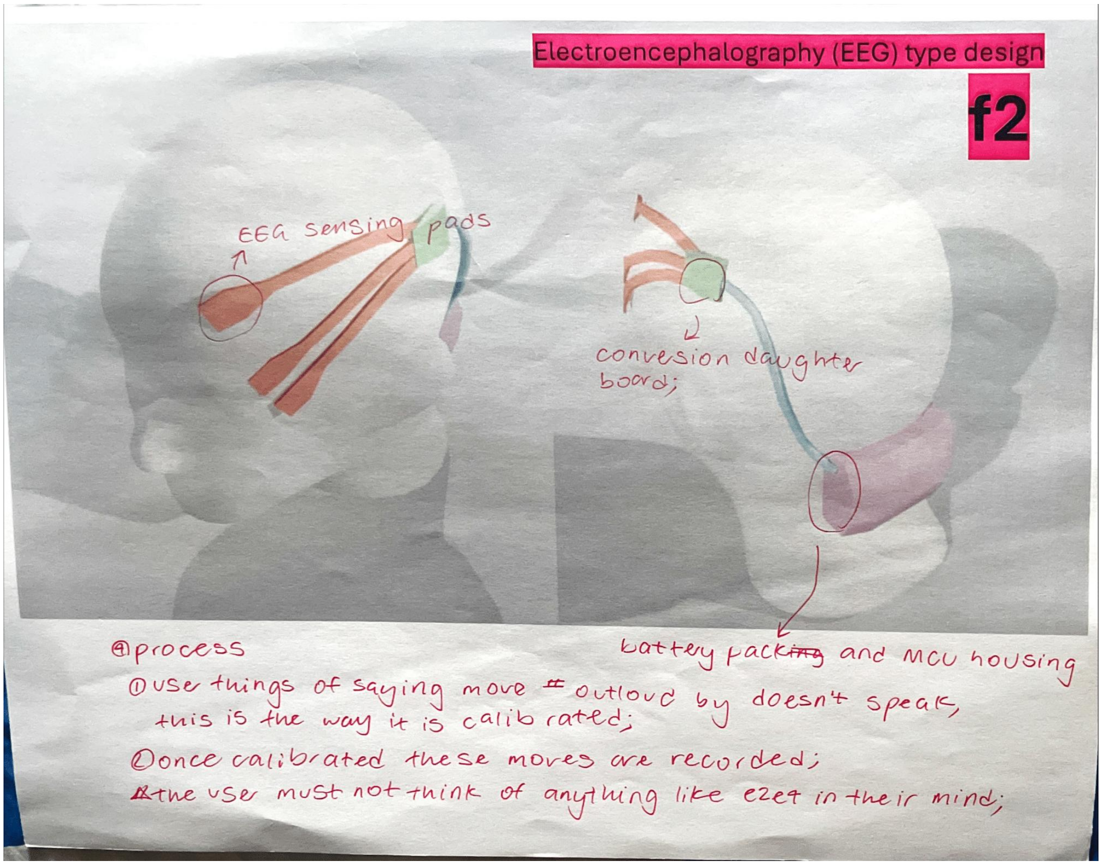
magnetic field

the reed switch works as above;

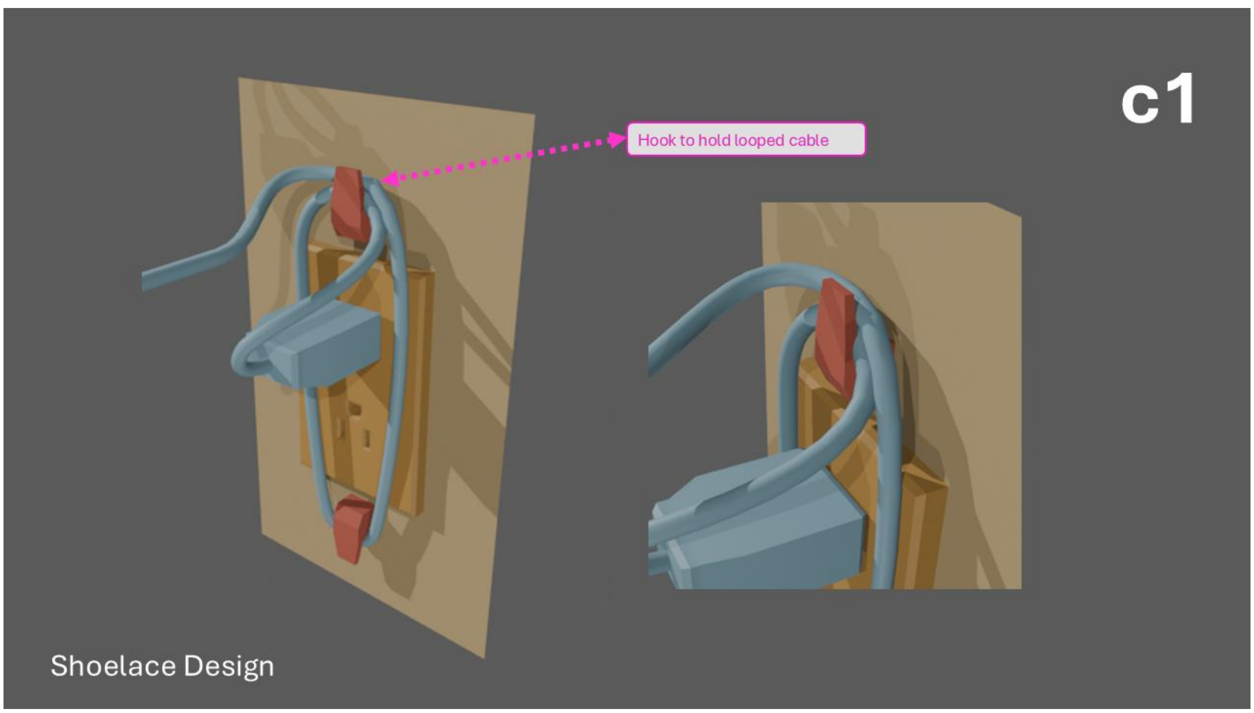
*the overall sensing is the same as the hall effect board;

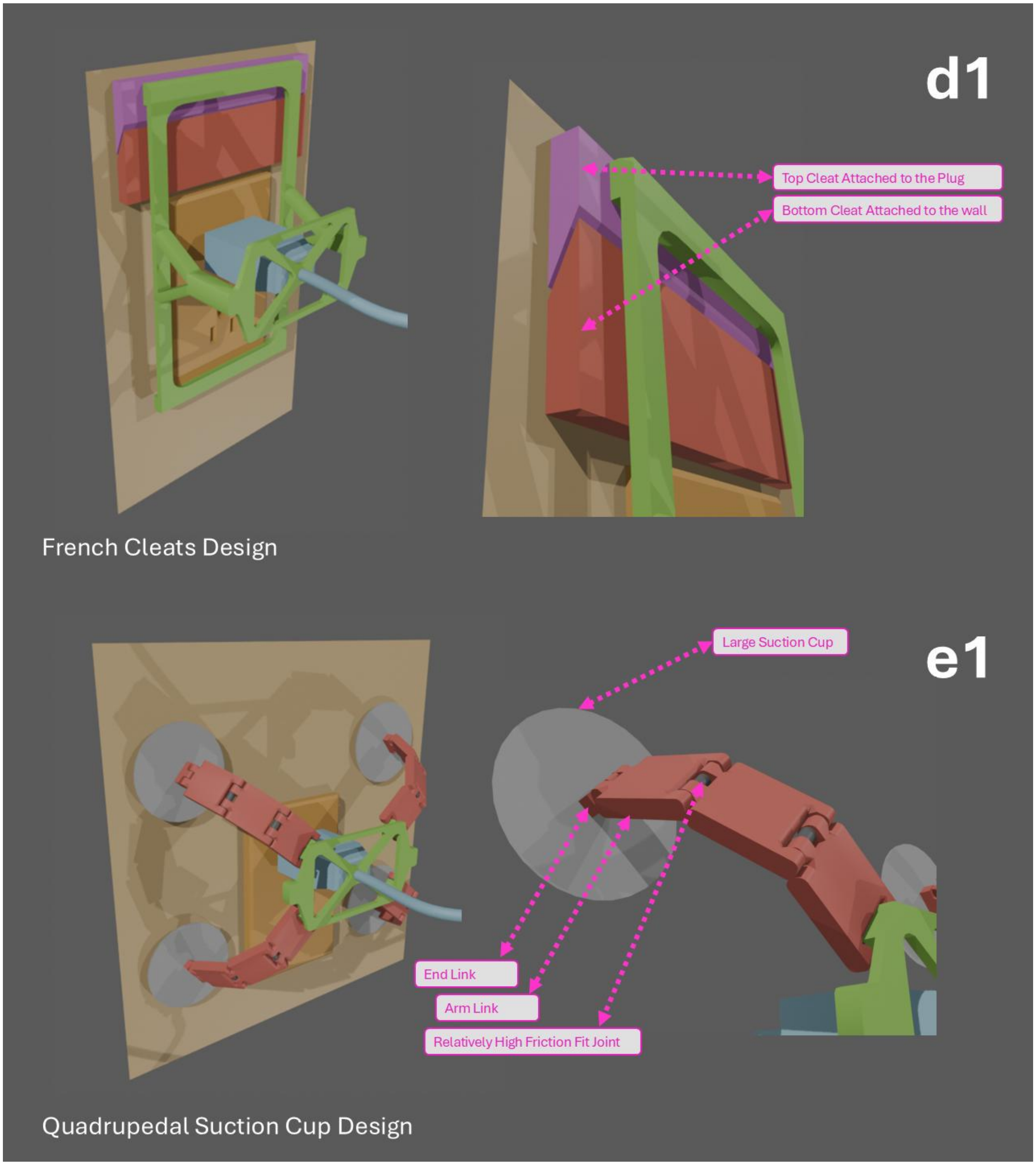

reed switch sensing array design
C2
menu controls for tuing like
① wiffi, BLE controls
② power controls
③ special moves controls, pawn promotions, castling
power button
from main board to the power control board;
to the screen board;

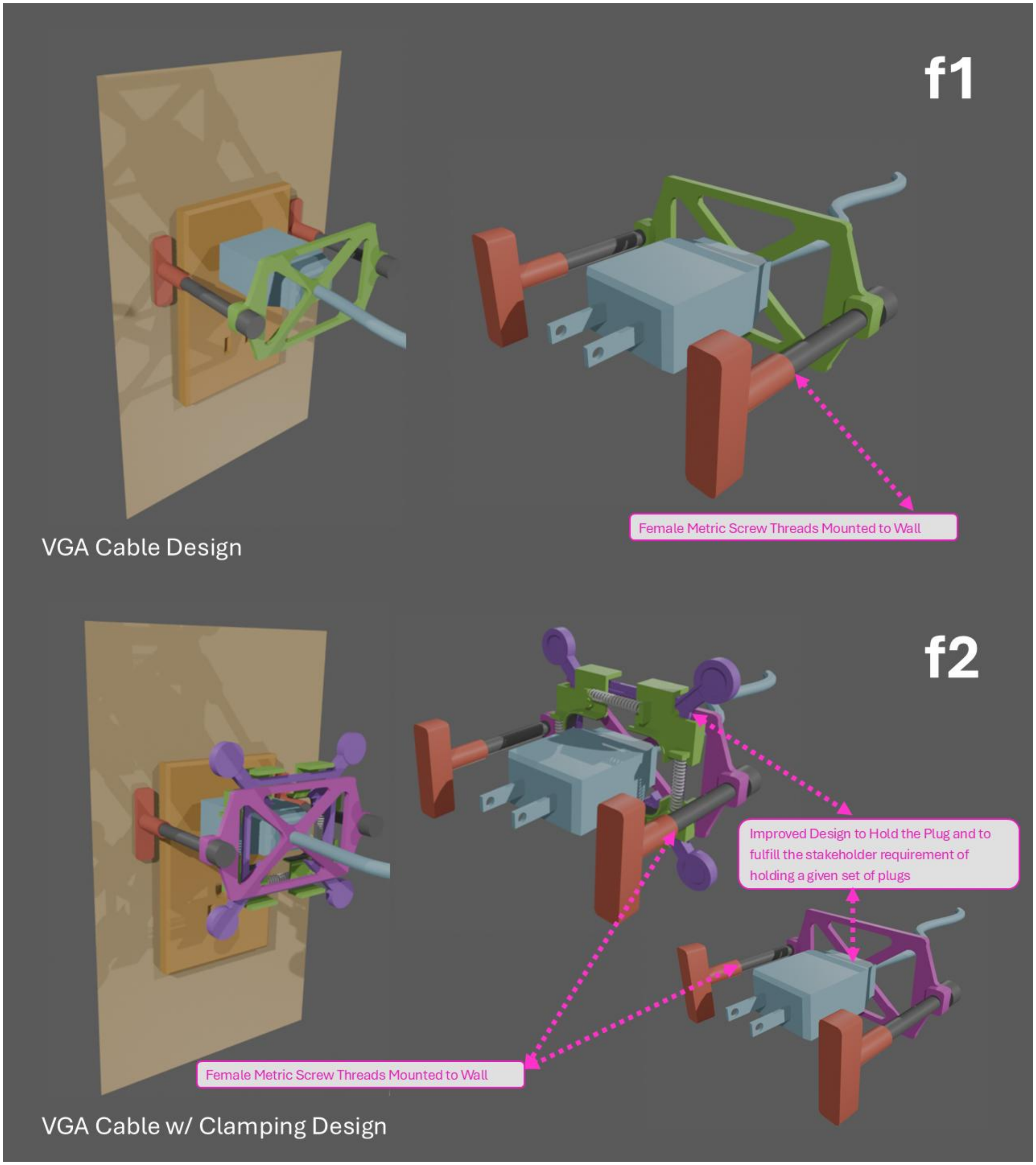

camera and computer vision design
f1
camera for real-time open-cv
camera for recording to ensure computer vision is accurate by acting as a backup;
• MCU, lithium polymer battery housing;
all devices BLE and wifi enabled;

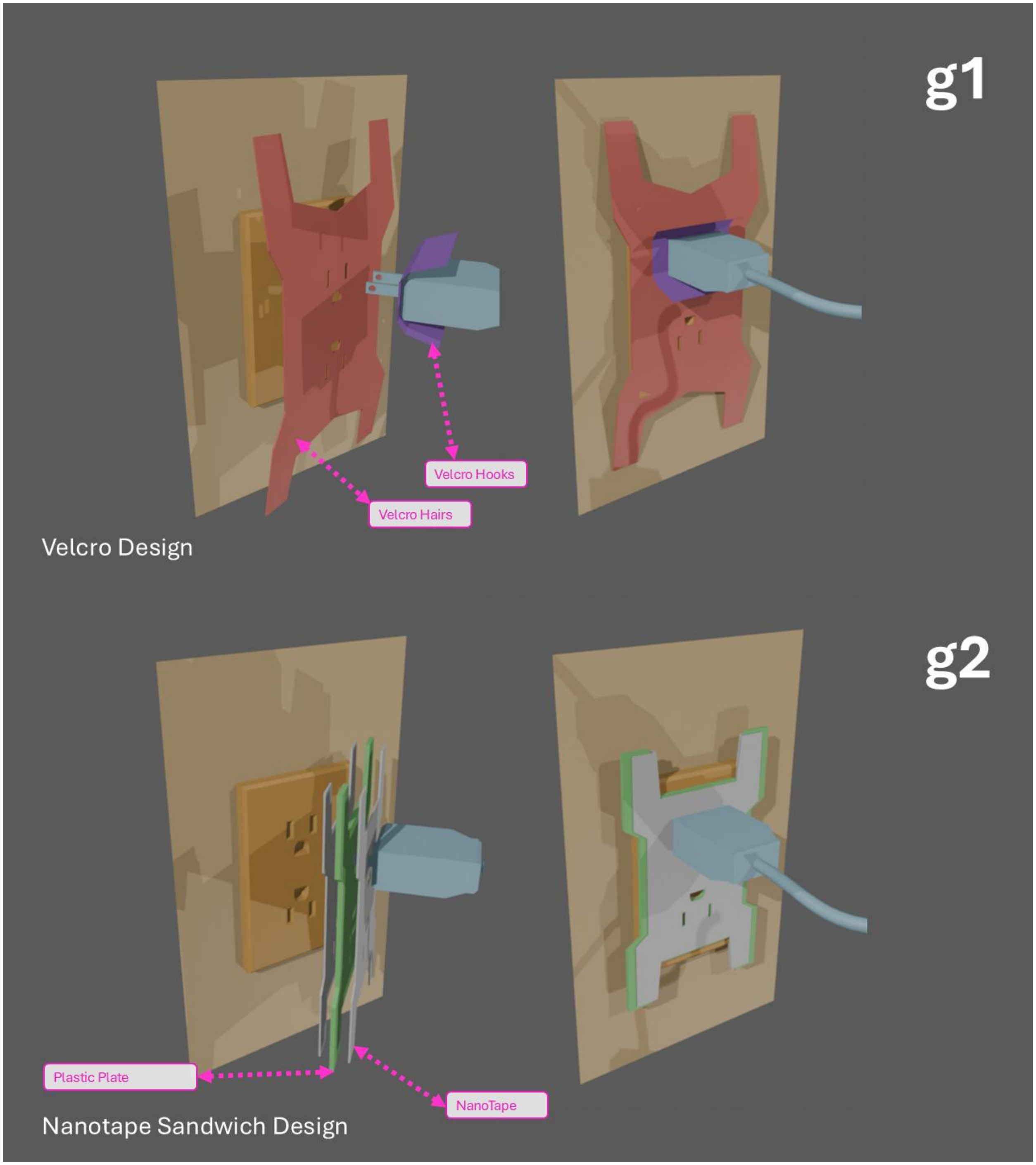


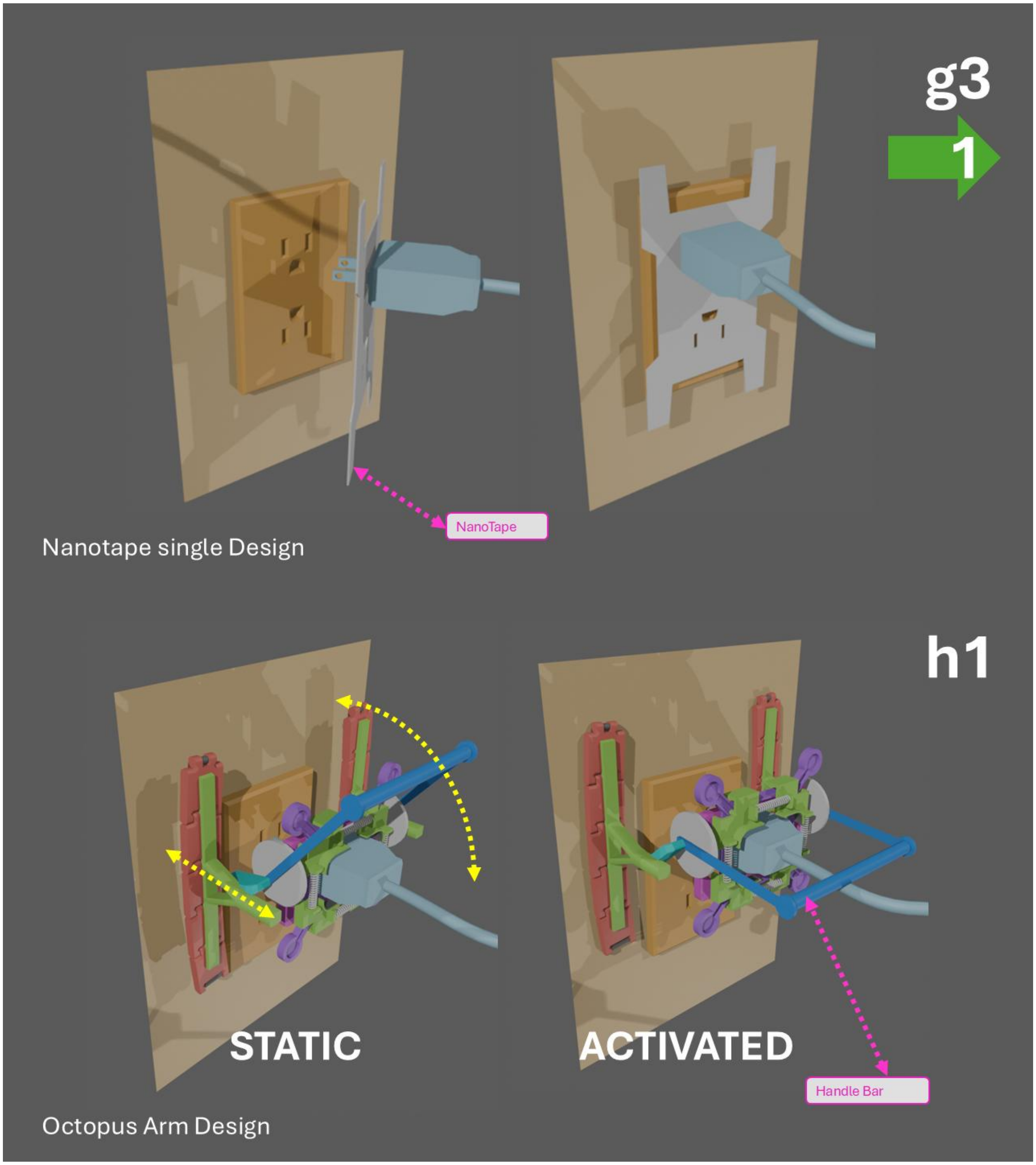
7.2 Alpha Designs in Detail

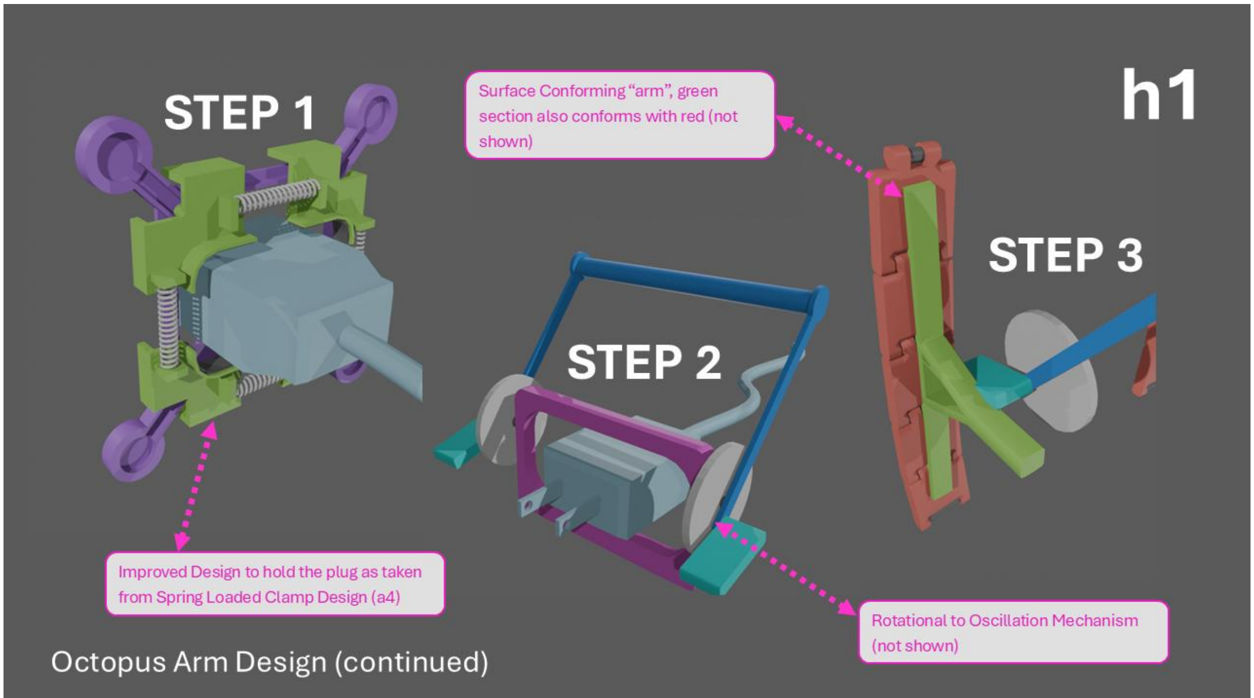



d1
Top Cleat Attached to the Plug
Bottom Cleat Attached to the wall
French Cleats Design
e1
Large Suction Cup
End Link
Arm Link
Relatively High Friction Fit Joint
Quadrupedal Suction Cup Design

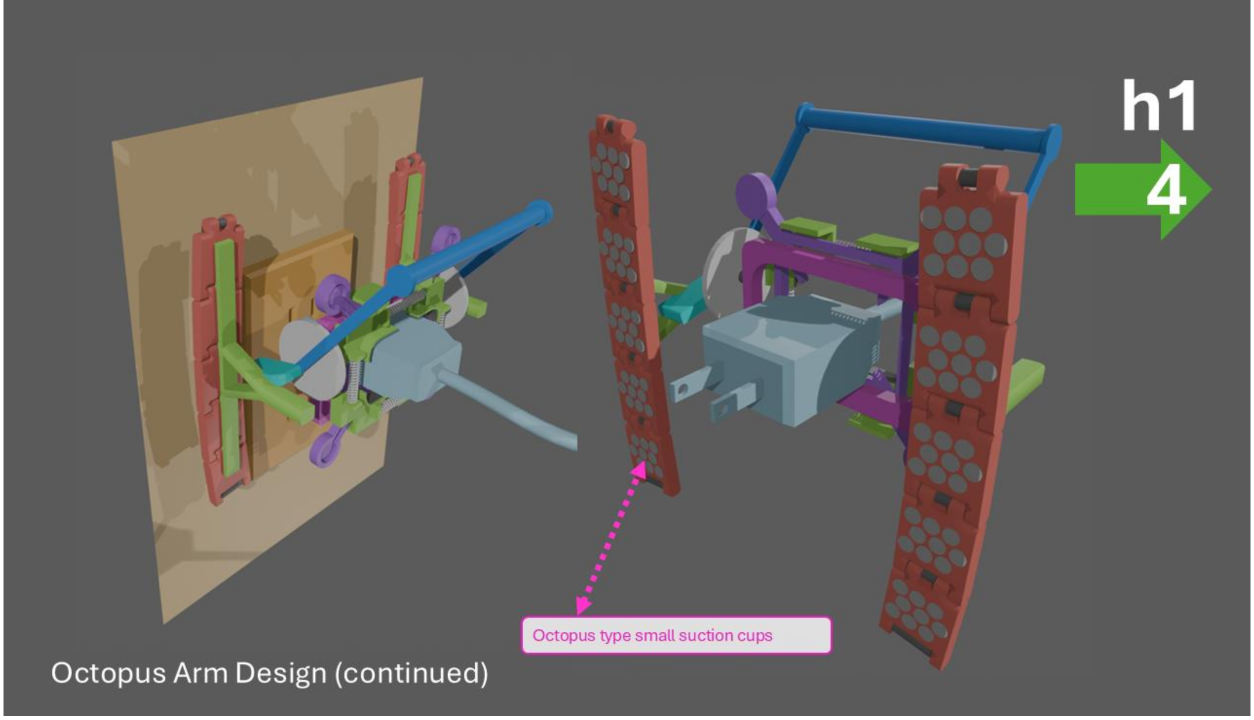

f1
Female Metric Screw Threads Mounted to Wall
VGA Cable Design
f2
Improved Design to Hold the Plug and to fulfill the stakeholder requirement of holding a given set of plugs
Female Metric Screw Threads Mounted to Wall
VGA Cable w/ Clamping Design


g1
Velcro Hooks
Velcro Hairs
Velcro Design
g2
Plastic Plate
NanoTape
Nanotape Sandwich Design


g3
1
NanoTape
Nanotape single Design
h1
STATIC
ACTIVATED
Handle Bar
Octopus Arm Design



Octopus Arm Design (continued)



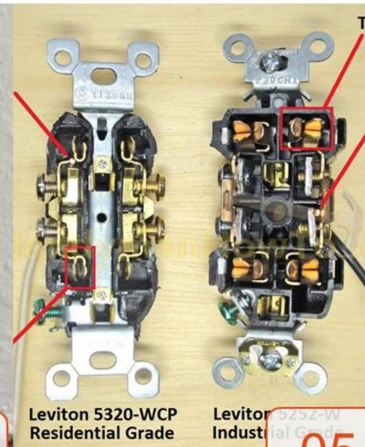
Octopus Arm Design (continued)

01

02

03

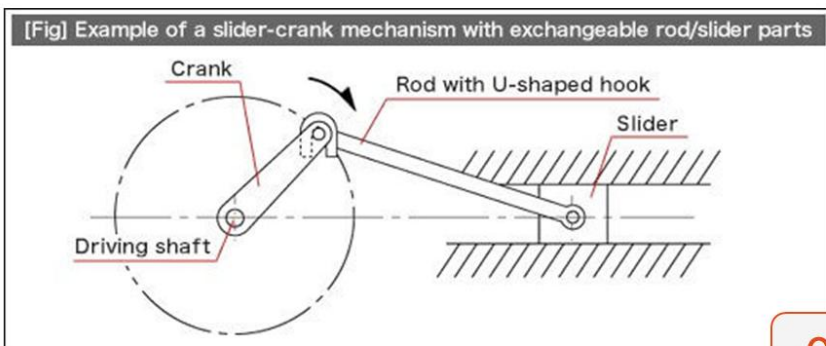
04



05

06

07



08

[08] *Rotary to Linear Motion | MISUMI Mech Lab Blog*. (2016). Accessed: Nov. 5, 2024. [Image]. Available: https://us.misumi-ec.com/blog/rotary-to-linear-motion/

IMAGE SOURCES

[01] *Rankie VGA Display Cable (10ft)*. (2020). Accessed: Nov. 5, 2024. [Image]. Available: https://www.airdriecomputer.com/products/rankie-vga-to-vga-cable-10ft

[02] *File:MagSafe1.jpg - Wikipedia*. (2017). Accessed: Nov. 5, 2024. [Image]. Available: https://en.wikipedia.org/wiki/File:MagSafe1.jpg

[03] *KOTTO Third Hand Soldering PCB Holder Tool Six Arms Helping Hands Crafts Workshop Helping Station Non-Slip Aluminum Base Wire Cutter Plier*. (2024). Accessed: Nov. 4, 2024. [Image]. Available: https://www.amazon.ca/Third- Soldering-Workshop-Non-Slip-Aluminum/dp/B079CHJQKH?th=1

[04] *Upside Down Plugs, Older Home*. (2021). Accessed: Nov. 4, 2024. [Image]. Available: https://www.reddit.com/r/electricians/comments/u1bw0y/anyone_know_why_i_have_a_few_of_these_upside_down/

[05] *What are "backstab" receptacles/outlets?* (2020). Accessed: Nov. 5, 2024. [Image]. Available: https://diy.stackexchange.com/questions/201207/what-are-backstab-receptacles-outlets

[06] *YOKIVE 20 Pcs Alligator Clip, Pre-Insulated Crocodile Test Clamp | Connecting Terminal, Great for Lab Testing (Red, Black, Silver, 2-Inch)*. (2024). Accessed: Nov. 4, 2024. [Image]. Available: https://www.amazon.sa/- /en/YOKIVE-Alligator-Pre-Insulated-Crocodile-Connecting/dp/B0BSBLH7Y6

[07] *Wikimedia Commons: Nanotape*. (2018). Accessed: Nov. 5, 2024. [Image]. Available: https://upload.wikimedia.org/wikipedia/commons/thumb/6/63/Nano_tape.jpg/1280px-Nano_tape.jpg

Octopi Suction Morph Chart

Function	Quadrupedal Suction	Shoelace	VGA Screw Mechanism	Velcro
Wall Attachment Mechanism	Suction cups	Rope	Screwed in	Sticking via Velcro
Plug Securing Mechanism	Solid surface behind the plug	The cord itself	Spring cage	Sticking via Velcro
Surface Conformity	Pressed manually	Rotated manually with mechanical advantage	Screwed in	Bends to conform around surfaces
Moderation of the Force of Attachment	Manual/pushing it harder	Mechanical advantage through a pulley system/manual	Screws/manual	Manual/pushing it harder

7.3 Time log for CIV102

Values below represent the time each person spent performing a given task, not the cumulative time spent as a group. Therefore, adding up final total times for each person does not yield the total time the group spent as a whole.

Names have been made into initials for privacy.

Tasks	Internal Deadline	Submission Deadline	MI	NF	Ayan
Preliminary	10/29/2024	---	1.5	1.5	2
Deliverable I Preliminary Meeting Includes Reading Design Document, Assigning Tasks, and Analyzing the rest of the project	11/3/2024	---	1	1	1
Find storage and building space	11/5/2024	---	0.5	0.5	0.5
Pick up build material	13/13/2024	---	---	---	0.5
Deliverable 1	11/9/2024	11/11/2024	3	2	1.2
SFD and BMD	11/9/2024	11/11/2024	0.5	1	---
Centroid and Second Moment of Area	11/3/2024	11/11/2024	1.5	---	---
FOS against flexural tension/compression failure	11/4/2024	11/11/2024	0.33	---	---
First Review	11/04/2024	11/11/2024	0.66	1	---
Second Review	11/05/2024	11/11/2024	---	---	1.2
Team Dynamics Survey	11/3/2024	11/11/2024	0.1	0.1	0.1
Design Report - Total	11/25/2024	11/25/2024	3.5	6	11.5
Introduction	11/25/2024	11/25/2024	---	0.5	---
Preliminary Discussion	11/17/2024	11/25/2024	1	1	1
Code review and design report analysis	---	11/25/2024	0.5	0.5	-
Iterations – Design Decisions	11/25/2024	11/25/2024	1	0.5	9
Iterations - Justification	11/25/2024	11/25/2024	0.5	3	1

Review	11/25/2024	11/25/2024	0.5	0.5	0.5
Supporting Calculations - Total	11/25/2024	11/25/2024	20	23.5	41.5
Part 1: Hand Calculations - Total	11/24/2024	11/25/2024	7	5	---
Design 0 Calculation (Load Case 1)	11/25/2024	11/25/2024	3	---	---
Design 0 Calculation (Load Case 2)	11/25/2024	11/25/2024	3	---	---
Diaphragm Spacing Calculations (Non linear)	11/25/2024	11/25/2024	1	5	---
Part 2: Programmed Calculations - Total	11/24/2024	11/25/2024	11.5	18.5	36.5
Code for intermediate calculations	11/24/2024	---	---	2.5	20
Cross Sectional Building Software – Framework code, master shape list	11/21/2024	---	---	9.5	9.5
Cross Section Code – Areas and Void area + fixes	11/21/2024	---	---	2	2
SFE of Design 0 for Load Case 1 and for your final design under Load Case 2.	11/23/2024	11/25/2024	5	---	2
BME of Design 0 for Load Case 1 and for your final design under Load Case 2.	11/23/2024	11/25/2024	5	---	2
Code output of all FOS values along the bridge.	11/23/2024	11/25/2024	---	3	---
Formatting and annotating code	11/25/2024	11/25/2024	1.5	1.5	1
Additional - Total	11/25/2024	---	1.5	---	5

Calculation Review for Final Design	11/25/2024	---	1.5	---	1.5
Additional Design Considerations	11/24/2024	---	---	---	3.5
Engineering Drawings - Total	11/27/2024	11/27/2024	8	9.5	1
Part 1: Good Copy of Final Bridge Design - Total	11/27/2024	11/27/2024	1.5	6.5	0.5
2D Matboard Cutting Plan	11/24/2024	---	---	0.5	---
Elevation, top, bottom, cross-section views	11/25/2024	11/27/2024	---	1	---
Splice, Diaphragm and connection details	---	11/27/2024	0.5	1.5	0.5
3D Models	---	11/27/2024	---	1.5	---
Formatting	11/27/2024	11/27/2024	1	2	---
Part 2: Construction Process - Total	11/27/2024	11/27/2024	6	1	0.5
Time Stamped photo evidence of construction session	11/27/2024	11/27/2024	3	0.5	---
Formatting	11/27/2024	11/27/2024	2	---	---
Review	11/27/2024	11/27/2024	1	0.5	0.5
Part 3: Timelog - Total	11/27/2024	11/27/2024	0.5	2	---
Timelog	11/27/2024	11/27/2024	0.5	2	---
Construction - Total	11/25/2024	11/25/2024	6.5	6	10.5
Obtaining Materials	11/20/2024	---	---	---	1
Drawing Members onto Matboard	11/24/2024	11/25/2024	1	1	1.5
Cutting Matboard	11/25/2024	11/25/2024	1	1	2.5
Scoring Glue Tabs	11/25/2024	11/25/2024	0.5	0.5	1

Glue round 1: Diaphragm edge 1 and making the deck piece	11/25/2024	11/25/2024	1	---	1
Glue round 2: Splice	11/25/2024	11/25/2024	0.5	---	0.5
Glue round 3: Diaphragm edge 2	11/25/2024	11/25/2024	0.5	0.25	0.75
Glue round 4: Diaphragm edge 2 - redo	11/25/2024	11/25/2024	0.5	---	0.5
Glue round 5: Fixes and top deck	11/25/2024	11/25/2024	1	1	1
Final adjustments	11/25/2024	11/25/2024	---	0.25	0.25
Clean up	11/25/2024	11/25/2024	0.5	0.5	0.5
Decoration	11/28/2024	---	---	1.5	---
Total			42.5	48.5	67.7

References

[1] “Longtermism.” Centre For Effective Altruism. Accessed: Apr. 11, 2025. [Online]. Available: https://www.centreforeffectivealtruism.org/longtermism

[2] W. MacAskill. “What is longtermism?” BBC Home - Breaking News, World News, US News, Sports, Business, Innovation, Climate, Culture, Travel, Video & Audio. Accessed: Apr. 11, 2025. [Online]. Available: https://www.bbc.com/future/article/20220805-what-is-longtermism-and-why-does-it-matter

[3] “Napalm, An American Biography.” Napalm, An American Biography. Accessed: Apr. 11, 2025. [Online]. Available: https://www.napalmbiography.com/#:~:text=Napalm%20was%20invented%20on%20Valentine's,soccer%20field%20that%20Independence%20Day.

[4] “History of napalm origins at Harvard | Harvard Magazine.” Harvard Magazine. Accessed: Apr. 11, 2025. [Online]. Available: https://www.harvardmagazine.com/2013/04/like-garlic-or-burning-matches

[5] “The invention of magnetic resonance imaging (MRI).” IEC. Accessed: Apr. 11, 2025. [Online]. Available: https://www.iec.ch/blog/invention-magnetic-resonance-imaging-mri

[6] “Stepwise refinement.” Department of Computer Science |. Accessed: Apr. 11, 2025. [Online]. Available: https://www.cs.cornell.edu/courses/JavaAndDS/stepwise/stepwise.html

[7] *Praxis II Lectures*. Prax. II Teach. Team, 2025. Lectures

[8] *Praxis I Lectures*. Prax. II Teach. Team, 2024. Lectures

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