Engineering Design Portfolio

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My Position of Engineering Design

Engineering design is an iterative process of refining solutions through creativity and technical feasibility. It is not a search for perfection, but a commitment to a defensible solution that minimizes system gaps. As an engineering design student, I take accountability for the trade-offs between stakeholder needs and for the limitations due to the physical constraints of the project.

My Approach to Engineering Design

1. **Iterative Opportunity Framing**
   I begin the design process by identifying and understanding the opportunity. However, I will iterate on my understanding of the problem as new stakeholder insights or technical constraints emerge.

2. **Stakeholder Mapping and Prioritization**
   I identify the stakeholders involved and, through continuous rethinking and team discussion, I categorize them into the main needs by prioritizing certain needs. I recognize that framing is an iterative process where trade-off between stakeholders may be made.

3. **Requirements and Evaluation Criteria**
   I set the functionality the solution should do through quality research.

4. **Evidence-based diverging and converging iterations**
   I do diverging and converging iteration with based on requirements and evaluation criteria developed.

5. **Prototyping**
   I create prototypes to generate evidence for further convergence. This phase can trigger a loop back to the framing or modelling stages if unanticipated failure modes are discovered.

6. **Accountable Execution**
   I create the design with care, understanding that the quality of construction directly impacts user satisfaction and safety. I take accountability for the design by ensuring all design decisions are justifiable and acknowledging its limitations.

7. **Integrate and test the product in context**
   An essential part of the engineering design process is to test whether the product works well in context. This step helps identity any further issues that were not anticipated for more iteration and improvement.

Why I got into Engineering Design?

For over a decade, I dedicated most of my free time to crafting because it brings my imagination to reality. Through the limited materials, tools, and repeated failures, I became more resourceful. It gave me a better sense of how to simplify and optimize a build with the constraints that I have. With that my interest for optimization grew.

I believe engineering design extend this process by optimising ideas into more functional, efficient solutions for more possibilities to exist in the real world. For example, optimizing for an aircraft that must be light and have enough power.

My Values

01 Quality

I believe a high quality product is the result of careful engineering and respect for users. Quality products are often more safe, durable, and easy to use to enhance user satisfaction.

Why Quality Matters to Me? | A *Glimpse into my Past Experiences*

Over the 11 years of crafting, I have attempted to build many of my ideas. Through making, failing, and correcting, I learned that only careful execution allowed my ideas to be built successfully and survive repeated use. With careful execution, quality is achieved.

02 Accountability

I recognize that any design choice have limitations. As an engineer, I am obligated to acknowledge these limitations and to not only make a design choice but to be able to justify why that choice was made over others.

Why Accountability Matters to Me?

Throughout my first year in Engineering Science, I realized that there are always limitations to a design. It is about minimizing the limitations within the time and physical constraints provided, taking accountability for these limitations, and still being able to defend for the design decisions made.

***Note**: all annotation about my values will be indicated in blue (for quality) and green (for accountability). All other annoations will be in red.*

The rest of the document will explain how my engineering design position arrived to this point.

Introduction

The purpose of this portfolio is to document my work and development as an engineering designer. Beginning in September 2025, my engineering design journey evolved through three main team projects. Through Praxis I, I explored an opportunity within the first-year engineering science community. Through CIV102 Bridge, I explored the more technical side of engineering design as we designed the best beam bridge to accomplish the assigned task. Lastly, through Praxis II, I shifted from exploring simpler localized issues to navigating multifaceted needs of communities in the Greater Toronto Area (GTA). From Praxis I to CIV102 Bridge to Praxis II, my personal position of and approach to engineering design has evolved from a dualistic search for a singular "correct" answer to a stage of relativism, where I view design as the disciplined management of trade-offs and the synthesis of technical rigor with intentional, defensible value-prioritization. Overall, this portfolio is organized to explain three project summaries with three CTMFs for each project illustrating a more in-depth view of how my approach the engineering design evolved through process of framing, diverging, converging, and representing.

Table of Context

My Position of Engineering Design as of September 2025

Engineering design is an process where creativity and technical feasibility are used to find the best solution to a problem.

My Approach to Engineering Design (from crafting experience)

1. **Find** the opportunity.
2. **Think** of a solution for the opportunity by picking one from an array of solutions I can think of. These solutions may be from YouTube, blogs, or inspirations in my own life.
3. **Create** the solution through building.

Annotations

In September 2025, I entered the Engineering Science program with a perspective rooted in crafting. My approach was dualistic; I used my crafting experience to pick what I thought was the "right" solution.

Praxis I: Exploring an Opportunity within the First-year Engineering Science Community (One-pager)

Project Context

The Praxis I focuses on the “splartz”, a minor annoyance in everyday life that can be improved, in the first-year engineering science community.

For this project, I was in a team with Addison Litvinchuk, Alina Zheng, Yvonne Luo, and Vaisnavi Prabaharan as shown in Figure 1.

Figure 1: Team bonding in December 2025

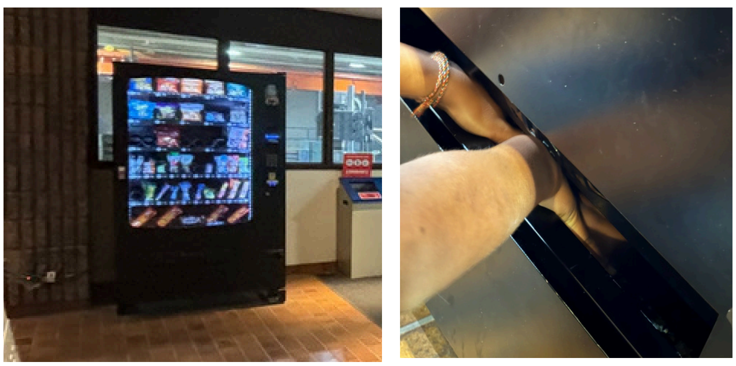

Figure 2: The hand of an engineering science student in the maximum opening of the vending machine flap in Sanford Fleming.

Our team focused on “improving the ease of product retrieval in Sanford Fleming Vending Machine” where we aimed to come up with a solution that reduced effort for users to reach to retrieve the product by finding the **“best”** opening mechanism to reduce hand force and strain and best product retrieval height while preserving the original vending machine functionalities. The vending machine is shown in Figure 2.

Annotations

As shown by my description of this opportunity, I believed engineering design was about finding the “best” solution, a solution that can accomplish everything I want with no sacrifices.

This is similar to the “Dualism” stage of Perry’s model of Intellectual Developement where I believed that all problems have a “correct” solution, so if I optimized every singular component “hand force”, “hand strain”, and "retrieval height", I would have that “correct” solution.

The Final Design

My team’s solution, as shown in Figure 3, to this opportunity is a vending machine with a one-way flap to the force of gravity on the product to push down the flap and fall onto the tray. There is a spring-hinged flap that is able to snap back to its closed position after the product passes through, such that no objects can pass through to prevent theft. The height of the snack retrieval height was also shifted up as much as possible to be closure to the ideal height to reduce physical exertion.

Key Design Considerations

Product Retrieval Height for Accessibility

Process: To ensure the solution was accessible to Engineering Science students, I researched for a "Retrieval Height" requirement. This metric was designed to prevent excessive strain by reducing trunk inclination. By synthesizing data from ergonomic research papers and CSA B651, I defined an operational range of 600mm to 1200mm.

Final Design Solution: The product features a centralized retrieval bay positioned as close to 900 mm as possible within the framing my team established. This height provides the best balance for users between the 5th and 95th anthropometric percentiles and wheelchair users, ensuring that the interface is reachable for both seated and standing users without overextension.

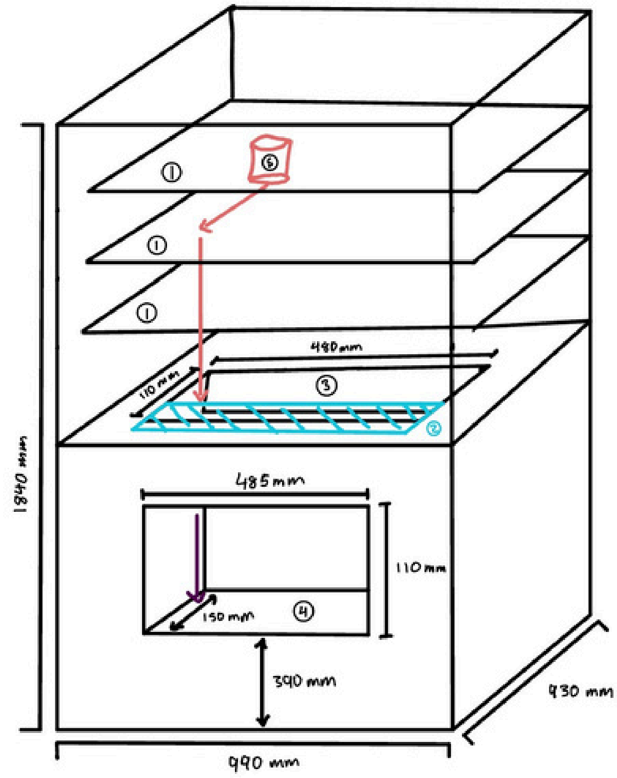

Figure 3: Final solution for the opportunity drawn by Alina Zheng for Praxis I.

***Annotation**: At this stage, I had a Dualistic mindset, believing that if I correctly followed authorities, such as research papers and industry standards, the "right" answer of 900 mm would be revealed. Looking back, just aimlessly averaging the lowest and maximum acceptable height range, may not be an optimal height as the decision to take the average is not backed up by evidence.*

No Door Feature with Wrist Ergonomics Considerations

Process: At the beginning of the project, my team experienced a design fixation focused on mechanical claw attachments for product retrieval. Through Reverse Brainstorming diverging technique, we generated more opening systems, including the no door system. For the “best” user experience with the opening systems, our team evaluated the wrist ergonomics of four distinct closure mechanisms: a standard flap, a lifting door, an automatic flap, and a no door system with a wrist flexion and extension tool to conclude with evidence that the no door system is the best.

Final Design Solution: The no door system has a interface as it minimizes the wrist's deviation from a neutral posture, reducing the risk of repetitive strain compared to traditional spring-loaded flap designs.

***Annotation**: This transition marks my evolution from "Crafting" to "Engineering." In September 2025, I operated with whatever idea that came to mind, usually not considering many other possibilities and not testing my ideas. However, this project introduced me to the Diverging, teaching me that initial fixation can affect the integrity of the design. I also learned to utilize prototypes for convergence through proxy testing to gather evidence for my ideas. This shift increased my sense of accountability for justifying design decisions with data.*

CTMF 1: Developing Evaluation Criteria for Framing - Lec 14 ESC101 [1]

The purpose of this analysis is to explore how I developed a requirement at the beginning stages of Praxis I and my reflection on it by the end of Praxis II. My team focused on the opportunity of altering the product retrieval area of the vending machine on the first floor of Sanford Fleming to make it more accessible for students. A component of accessibility is the height of the product retrieval area. At the point of developing the height evaluation criteria, I was influenced by a dualistic mindset, believing that the average of two extreme edge is the best solution. Through describing, interpreting, and reflecting on this observation, it highlights the importance of intentional value-prioritization instead of aimless averaging numbers.

What?

To develop this product retrieval height evaluation criteria, I averaged the minimum and maximum height that I found through research. To determine the minimum height, I gathered research from research papers and anthropometric data to calculate a maximum height of 600 mm. For the minimum height, I gathered data from Accessible Design Standard from CSA for a maximum height of 1200 mm. So, my evaluation criteria for the product retrieval height was, the closer the product retrieval height is to 900 mm as shown in Figure 5, the better.

[5.3] For the optimal product retrieval height
With the minimum height of 600mm from 5.1 and the maximum height of 1200mm from 5.2, the optimal height of product retrieval is determined to be the average of the two extremes.

$$\boxed{Optimal\ Product\ Retrieval\ Height = \frac{600\ mm + 1200\ mm}{2} = 900\ mm}$$

Figure 4: The calculation for the product retrieval height evaluation criteria from 600 mm and 1200 mm.

Table 3: Goal 2 - Adjust the product retrieval height of the vending machine, desired by primary stakeholders.

Requirements	Evaluation Criteria
R210: Purchased products shall be between 211mm and 1200mm above the ground. Limits retrieval height of product to maximum from [6] and minimum such that it is improved from measured null height of 211mm.	EC211: Closer retrieval height is to 900mm from ground.
R220: Purchased products shall be retrieved with a reach distance	EC221: Less obstruction.

Figure 5: The product retrieval height evaluation criteria of 900 mm calculated in Figure 4.

So What?

This event reveals that I was operating in the Dualism stage of Perry's Model while developing evaluation criteria for Praxis I. I viewed "Authority", which are the standards and research papers in this case, as the only source of "truth". With that "truth" of minimum and maximum height, I assumed simplistically that the exact middle of a range was the single best answer. However, averaging the values failed to account for the weight of each height. In this case, the maximum height was set to accommodate for people in wheelchairs who cannot reach high up. On the other hand, the minimum height was set to accommodate for standing people. Since the stakeholders are first-year engineering science students who are mostly standing people, weighing the importance of the maximum and minimum height the same likely resulted in more discomfort and worse ergonomics for most stakeholders. This event shows the importance of understanding the stakeholders' actual needs and taking that into consideration when finding the most important metrics to consider when framing. This analysis highlights how my early process lack of relativist thinking: by choosing the average, I treated the requirement as a discovery of a fact rather than a decision that carried inherent trade-offs for different stakeholder groups. I realized that averaging is often a way to avoid the responsibility of choosing which stakeholder needs to prioritize.

Now What?

Moving forward, I will move beyond simple averages by using weighting stakeholder needs during the framing process. This will allow me to acknowledge and deal with the conflicting needs of different user groups more effectively. Overall, I learned that it is not always the simple average that is the best decision choice, it is about intentionally minimize design limitations for the prioritized stakeholders.

Overall, this event shows my transition from a student who relies on mathematical averages to avoid difficult design choices to an engineer who uses intentional prioritization to serve specific stakeholder needs. It demonstrates my shift from seeking a "correct" fact to making a defensible design that accounts for the stakeholder trade-offs.

CTMF 2: Reverse Brainstorming - 16 Divering Tool ESC101 [1]

The purpose of this analysis is to explore the impacts of first stage of diverging in Praxis I on expanding our crafting mindset from before Praxis I and the lessons I learned from it. My team focused on the opportunity of altering the product retrieval area of the vending machine on the first floor of Sanford Fleming to make it more accessible for students. Before the first diverging with reverse brainstorming, my team and I were fixated on the a solution similar to a scooper as we did not see any alternate option; however, this was proven wrong with reverse brainstorming, which challenged and broke many of our initial assumptions about the solution. Through describing, interpreting, and reflecting on this observation, it highlights the importance of using diverging tools in the engineering design process to produce innovative solutions.

What?

When our team was first introduced to the opportunity, which is hands have trouble fitting into the vending machine opening, the natural thing that came to mind was an extension tool of some kind because we used an extension and claw-like method to get our snacks out. However, through reverse brainstorming where we focused on making the problem worse, the no door idea came up to worsen the anti-theft mechanism, as shown in Figure 6. That inspired the idea of adding another layer of anti-theft mechanism above the opening, leading to our final design of the one-way flap snack chute.

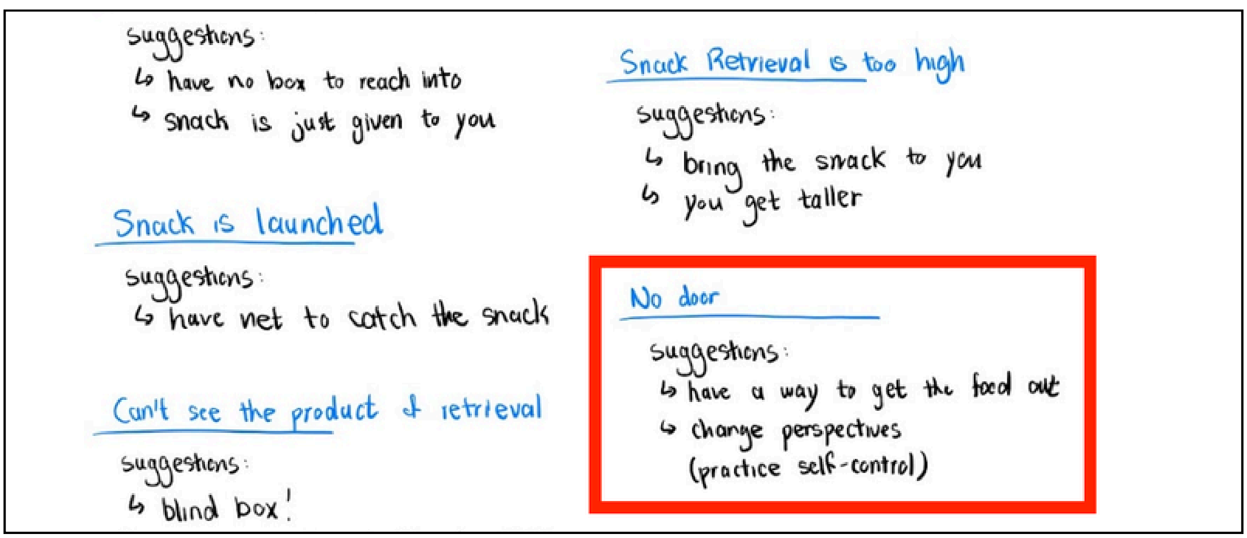

Figure 6: A screenshot of my team's reverse brainstorming notes with the "no door" assumption boxed in red.

So What?

This event marks a shift in my evolution from a hobbyist crafter to an intentional engineering designer. In September 2025, my position heavily relied on my mental array of past experiences; this event made me realizing that only relying on my crafting intuition of the claw was actually a form of anchoring bias that limited the design's potential. Within the team, by allowing ourselves to be "inspired" by a single initial idea, we risked the integrity of the project because there are many possibilities within the design space that have not explored yet that can be better as shown in this case. This realization was the first time I consciously chose to trust a formal process over my own initial "gut feeling." This analysis demonstrates that the value of diverging tools is not just "creativity," but de-biasing. It illustrates how I moved from a linear "Idea to Build" approach to a non-linear approach where I intentionally attacked my own assumptions to find a more elegant, simpler solution.

Now What?

Moving forward, I will not treat my first inspired solution as the foundation of my design. I will intentionally incorporate a diverging tools such as reverse brainstorming to break assumptions to get fully realize the design space.

Overall, reflecting on this pivot from the claw to the one-way flap shows the beginning of my evolution toward a more rigorous engineering mindset. It was the moment I stopped being just a maker who builds what they imagine or is inspired by. Instead, I started being an engineer design student who intentionally uses systematic tools to define what is possible.

CTMF 3: Proxy Testing - Lec 28 ESC101 [1]

The purpose of this analysis is to explore my transition from using prototyping as a tool for visual display to using it for empirical evidence generation. In my September 2025 position, I viewed prototypes solely as functional creations that translated my imagination into reality. However, during the design of a vending machine retrieval interface, I progressed toward using prototypes to quantify human movement and justify design selections through primary data when existing research was unavailable. Through describing, interpreting, and reflecting on this observation, it highlights my progression from subjective crafting to evidence-based engineering.

What?

To converge between the final six design concepts near the end of Praxis I, I proposed a wrist flexion and extension proxy test to quantify the ergonomics of different door opening mechanisms. I created a wrist angle measuring device with green construction paper and wire as shown in Figure 7. I was able to measure the maximum wrist flexion and extension different participants underwent for each opening mechanism as shown in Figure 8. This allowed my team to select a no-flap vending machine opening design as it minimized angle of wrist flexion and extension, indicating best for wrist ergonomics.

Figure 7: A wrist flexion and extension measuring device setup used for the wrist ergonomics proxy tests.

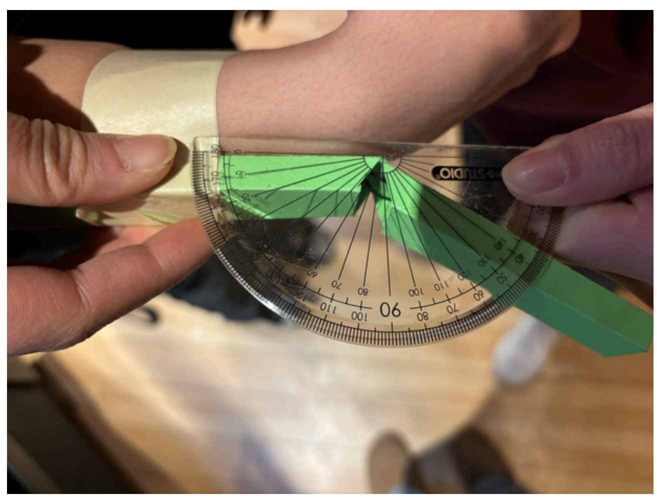

Figure 8: Measuring the wrist extension with a protractor.

So What?

This event marks my evolution from intuition to technical rigor. Before September 2025, my crafting approach would have relied on my own intuition and experience to guess if a design worked well in comparison to another. Through this event, I introduced more technical rigor by collecting data from actual testing, moving from opinions to defensible claims. This analysis highlights that I began to value taking accountability for my design decisions by gathering justifiable evidence through proxy testing to defend my solution. Through this experience, I learned that imagination is insufficient for engineering design if it is not validated by evidence. To generate the evidence, I can build to generate evidence rather than just building to showa proxy test. Overall, this has widened my idea of creating prototypes.

Now What?

Moving forward, I will intentionally design prototypes to isolate and test specific variables whenever research is unavailable. This approach will allow me to maintain accountability for my decisions by ensuring every design decision is backed by data.

Overall, this transition from crafting for the self to prototyping for the data represents a maturation of my engineering design approach. It shows that I have moved from a position of personal imagination to a position of accountability, where my builds contributes to the defensibility of the final solution.

My Position of Engineering Design by the end of Praxis I

Engineering design is an iterative process of perfecting solutions through creativity and technical feasibility.

My Approach to Engineering Design (from crafting experience, Praxis I)

1. **Identify** the opportunity from experience.
2. **Frame** how solutions should theoretically work through quality research (from standards).
3. **Diverging and Converging iterations** to narrow down to a few designs with a focus on feasibility.
4. Create and use existing **prototypes** to compare through testing.
5. **Build** the product with care to increase the quality of the product.

Annotations

By the end of Praxis I, my position was still rooted in Dualistic but has envolved from the beginning of the semester. I still believed that through enough high-quality research and creative ideation, an engineer could discover the "correct" solution. However, I recognized the role of diverging in reducing bias and coming up with more elegant solutions. I also recognized prototypes' use as a verification tool instead of just display a functional solution.

CIV102: Exploring the Technical Side of the Engineering Design (One-pager)

Project Context

The goal of the CIV102 bridge is the design a bridge that spans 1200 mm using matboard and contact cement as shown in Figure 9. The objective of this bridge is to support the maximum moving train load while minimizing the total mass of the bridge.

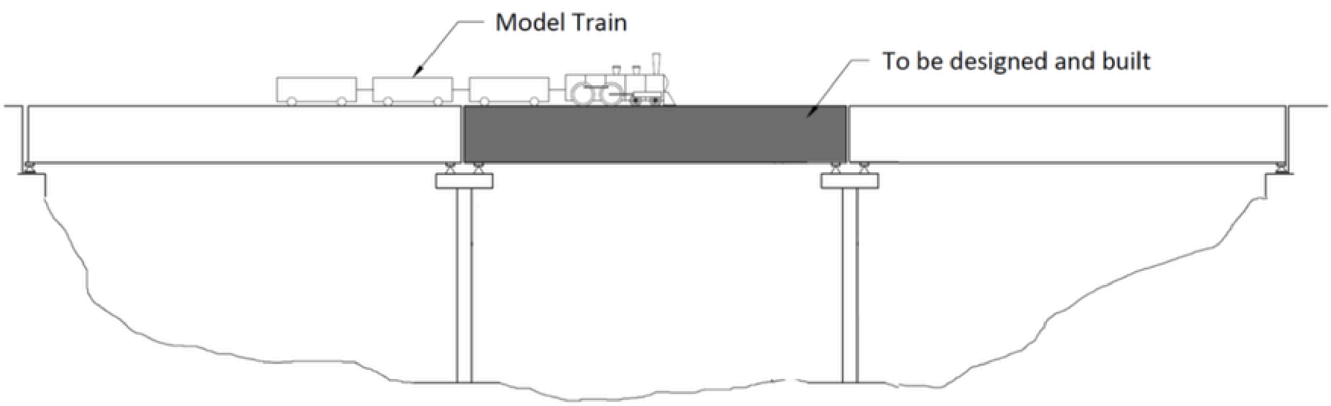

Figure 9: Diagram from "Bridge Design Project" document

For this project, I was in a team with Eraj Badar and Xueqi Yang as shown in Figure 10.

Figure 10: Team picture taken in November 2025 before Bridge Testing.

The Final Design

Our team's final design splits the bridge into three sections where there are two end cross-sections , as shown in Figure 11, and the one middle-cross section, as shown in Figure 12. The middle cross-section of the bridge consists of two long webs to handle bending moments, because the middle is where the bridge experience the most bending moment. The end cross-sections has both a top and bottom flange to resist against shear, because this is where the bridge experience the most shear through our analysis.

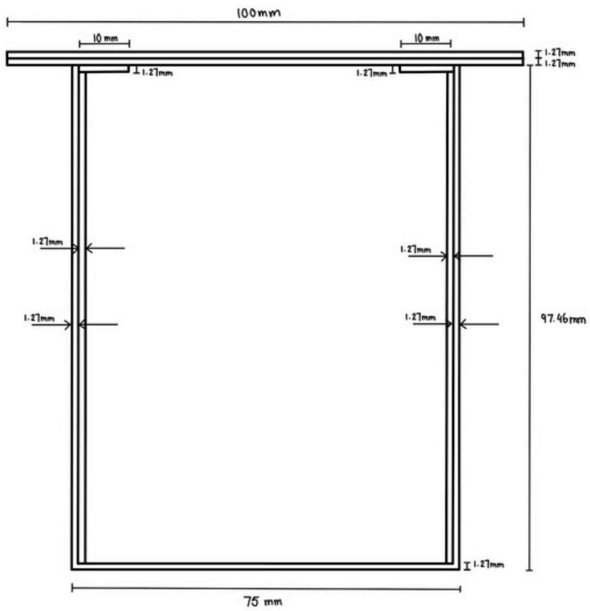

Figure 11: The end cross-section of the bridge.

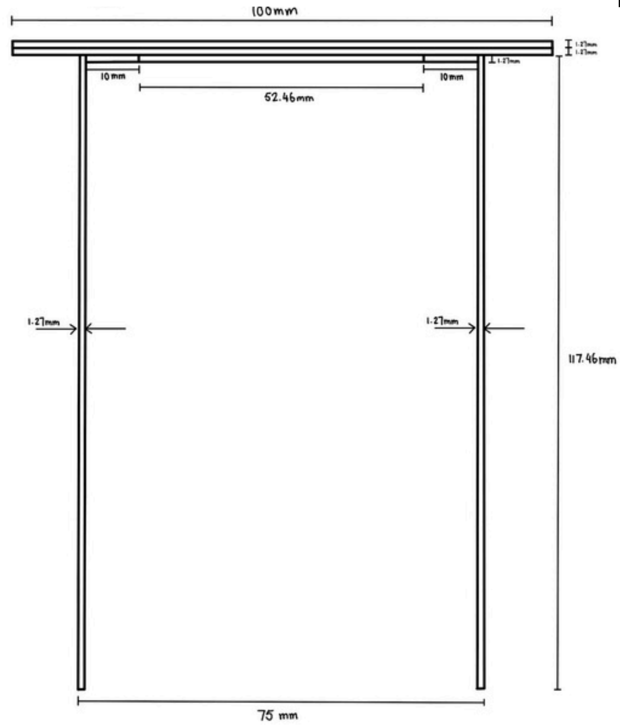

Figure 12: The middle cross-section of the bridge.

Key Design Considerations

Long Web Optimization for Failure Mode Management

Process: To maximize the bridge's Strength-to-Weight ratio, our team coded a MATLAB simulation where we mapped internal forces across the 1200 mm span of the bridge. Through this simulation, we determined longer web optimized the overall factor of safety of the bridge the most.

Final Design Solution: The final bridge features has long webs optimized for shear and buckling resistance. This specific geometry allowed us to increase the factor of safety from 0.84 from the baseline design to 2.38 in our final design.

***Annotation**: In Praxis I, I viewed design through a Dualistic lens, looking for a "best" height by averaging static standards. In CIV102, my position evolved into Early Relativity. I realized there is no "correct" bridge height; rather, there is an optimal configuration derived from physical constraints.*

Splicing Limitation

During the construction phase, we encountered a material constraint where the standard matboard dimensions we were given were insufficient for a single-piece 1200 mm span. To maintain the design dimensions, I joined multiple web and flange sections to cover the 1200 mm span. During the physical testing of our bridge, these spliced sections of the web and flange are shown to be the failure points of the bridge, leading to a significantly lower failing load than predicted.

***Annotation**: This project was my first encounter with the discrepancy between simulation and reality. In Praxis I, I operated under the belief that a "correct" design would inherently succeed if supported by solid research; I did not perform physical verification after converging to a solution. However, CIV102 demonstrated that a mathematically good design is subject to unanticipated failures, such as splicing. This experience taught me that verification in context is an essential component of the engineering process to ensure design quality and to identify overlooked variables before implementation.*

CTMF 1: Attribute Listing - 16 Diverging Tool ESC101 [1]

The purpose of this analysis is to explore how my approach to diverging evolved from generating holistic shapes to systematically decomposing a design into manageable variables in CIV102 bridge project. In my September 2025 position, I viewed structures as holistic units; for example, a bridge would just be one bridge. However, by decomposing a structure into independent technical variables, I can identify the performance levers to optimize a design. Through describing, interpreting, and reflecting on this observation, it highlights my progression from random intuitive selection to systematic decomposition.

What?

We used Attribute Listing to decompose the bridge into its independent variables: flange width, web height, glue tab size, and thickness. This allowed us to adjust each variable at each stage of the diverging process to identify the most beneficial variable to adjust at that point in time during converging. This process ensured that my team and I are mostly going towards the right direction with each step instead of aimlessly redesigning the entire bridge architecture.

Possible Adjustments:

- Increase / decrease height of webs
- Increase / decrease width of top flange
- Remove / keep the bottom flange
- Adding another layer of matboard to the top flange
- Adding another layer of matboard to the bottom flange
- Adding another layer of matboard to the webs
- Increase / decrease glue tab size

Figure 13: The independent variables that my team and I broke down to test for during each diverging iteration of the cross-section design.

So What?

This event marks a shift in my evolution from an engineering designer who relies on generating a singular holistic solution to one who utilizes systematic deconstruction to manage complexity. In Praxis I, my diverging was rooted in breaking assumptions to find a new type of solution. In the CIV102 bridge project, we are not looking for new type of solutions since we are constrained to make a beam bridge. Attribute Listing allowed for a more systematic exploration as ideas get more technical with more constraints. By seeing the bridge as a collection of variables rather than a singular idea, it prevented the team from throwing away a good concept just because one part of it failed. Instead, we could isolate and identify what worked about each concept. This analysis demonstrates that diverging is not just about more ideas, but about better-combined ideas for optimization. It illustrates my move toward a more accountable engineering mindset where I can justify why I am changing a specific part of a design to achieve a desired outcome.

Now What?

Moving forward, I will use decompose complex opportunities to simplify the process of optimizing systems. I will ensure that I identify all technical variables of a project before committing to a specific design, allowing for a more thorough reevaluation of every possible variable.

Overall, this shows my growth from generating holistic designs to systematically decomposing a design into manageable variables as a tool for innovation.

CTMF 2: Inductive Mathematical Prototyping - Lec 20 ESC101 [1]

The purpose of this analysis is to explore my transition from seeking a singular "correct" design to understanding engineering as a series of calculated trade-offs for an optimized solution. In September 2025, I viewed design as a search for a hidden "perfect" solution. However, through the mathematical modeling of our bridge, I progressed toward a Relativist perspective, realizing that design is not about finding the "right" solution, but about balancing conflicting components, such as mass and strength, for an optimized solution. Through describing, interpreting, and reflecting on this observation, this highlights my progression from Dualistic certainty to Early Relativism.

What?

We converged on our final bridge dimensions through an Inductive Prototype. Xueqi and I coded a MATLAB model that generated the Bending Moment and Shear Force Envelopes. This mathematical prototype allowed us to simulate failure predictions for each concept from our diverging process, including buckling, shear, and tension. By adjusting technical variables like web height and flange thickness in the code, we could see exactly how adjusting one variable shifted the overall Factor of Safety (FOS). Overall, the mathematical prototype was able to help my team improve the overall design significantly as shown from the change in overall factor of safety from Figure 14 to Figure 15.

FOS Results for Load Case 1

$\text{FOS}_{\text{compression}} = 1.037$	$\text{FOS}_{\text{shear matboard}} = 2.67$	$\boxed{\text{FOS}_{\text{case 1 buckling}} = 0.840}$	$\text{FOS}_{\text{case 3 buckling}} = 5.08$
$\text{FOS}_{\text{tension}} = 4.36$	$\text{FOS}_{\text{shear glue}} = 7.48$	$\text{FOS}_{\text{case 2 buckling}} = 4.06$	$\text{FOS}_{\text{shear buckling}} = 3.51$

Figure 14: Results from using the mathematical prototype to analysis the first design which has an overall factor of safety of 0.840.

FOS Results for Middle Cross-Section when tested with Load Case 2 Base Case

$\boxed{\text{FOS}_{\text{compression}} = 2.38}$	$\text{FOS}_{\text{shear matboard}} = 5.65$	$\text{FOS}_{\text{case 1 buckling}} = 28.7$	$\text{FOS}_{\text{case 3 buckling}} = 18.37$
$\text{FOS}_{\text{tension}} = 3.85$	$\text{FOS}_{\text{shear glue}} = 32.6$	$\text{FOS}_{\text{case 2 buckling}} = 23.9$	$\text{FOS}_{\text{shear buckling}} = 3.14$

FOS Results for End Cross-Sections when tested with Load Case 2 Base Case

$\text{FOS}_{\text{compression}} = 2.44$	$\text{FOS}_{\text{shear matboard}} = 5.49$	$\text{FOS}_{\text{case 1 buckling}} = 9.24$	$\text{FOS}_{\text{case 3 buckling}} = 38.0$
$\text{FOS}_{\text{tension}} = 8.23$	$\text{FOS}_{\text{shear glue}} = 15.66$	$\text{FOS}_{\text{case 2 buckling}} = 24.5$	$\text{FOS}_{\text{shear buckling}} = 4.34$

Figure 15: Results from using the mathematical prototype to analysis the final design which has an overall factor of safety of 2.38.

So What?

This event marks a shift from Duality to Early Relativism mindset, where I realized that there are different and equally “correct” ways to optimize the system. Through mathematical prototyping, I observed that there was no "perfect" bridge because similar performance can be achieved in different ways. For example, increasing the factor of safety in shear can mean decreasing the factor of safety in compression when only a fixed amount of material is provided. Bridges that are limited by shear or compression can have similar performance, so no one is better than the other. Through my team’s internal iterations, I learned that the engineering design process is about balancing the reward and sacrifice. This moved me away from the Dualistic belief that the "best" bridge was waiting to be discovered as in Praxis I with the no door decision. I learned as an engineering designer, I should be able to decide and justify how to allocate limited resources to maximize the specific rewards required by the project constraints instead of focusing on finding the “perfect” solution.

Now What?

Moving forward, I will utilize Inductive Prototyping to decide on the optimal ways to improve the design. I will generate multiple versions to compare how different "sacrifices" affect the overall system performance. This ensures that my final design decisions are not just functional, but the most defensible choice among a range of valid relative options to increase accountability.

Overall, this transition represents a maturation of my engineering position. I have moved from looking for the "right" answer to understanding that every design is a unique balance of constraints, and my responsibility is to take accountability for the specific balance I choose.

CTMF 3: Physical Prototyping for Verification - Lec 29 ESC101 [1]

The purpose of this analysis is to explore how my understanding of physical prototyping evolved from a representational model to a critical stage of engineering verification. In September 2025, I viewed the build as the end of the engineering design journey as a way to represent my solution. However, the discrepancy between my theoretical calculations and the physical performance of the CIV102 bridge shifted my perspective. Now, I recognize that physical verification is a beneficial step for transforming an idealized concept into a high-quality product. Through describing, interpreting, and reflecting on this observation, this highlights my progression from viewing physical prototyping as a final representation to a verification step in the engineering design process.

What?

My team build our final design from the MATLAB mathematical prototypes into a physical bridge using matboard and contact cement. While our mathematical model predicted a failure load of 1092N, our physical bridge failed at only 133N. This failure was caused by real-world variables our code did not account for, such as the structural splices necessitated by constrained matboard lengths as shown in Figure 16, the inconsistent performance of the glue joints from error in glue application, and likely many more than my team and I did not investigate further.

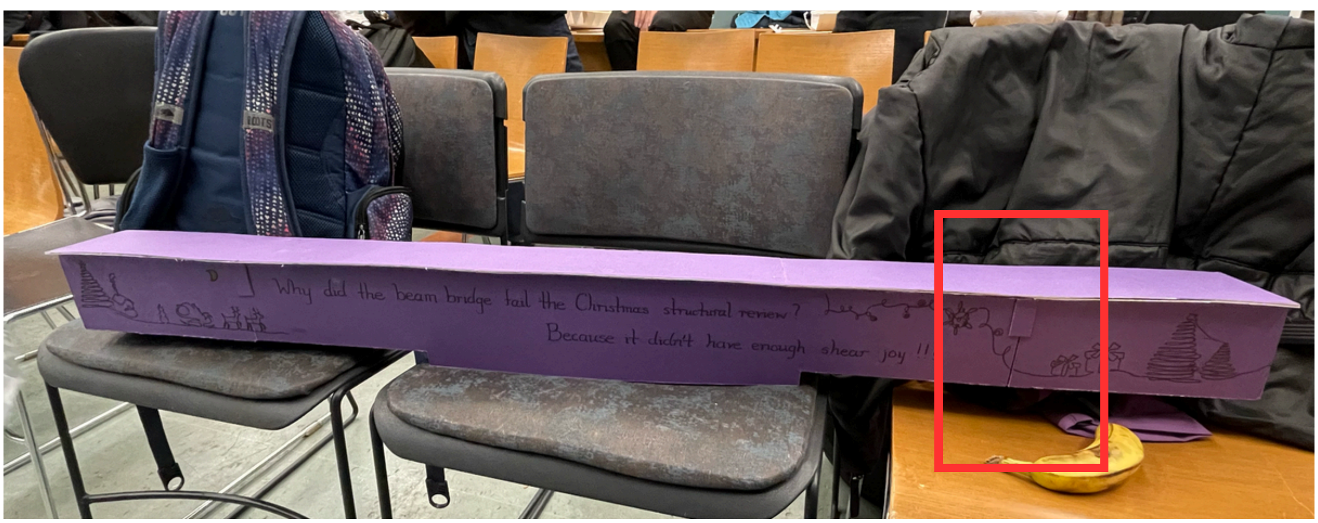

Figure 16: The red box shows the splice in the bridge that failed during testing.

So What?

This event revealed the critical verification step that I missed in my understanding the engineering design process before this stage. Up to the point before testing the physical bridge, I treated the test as a step to "confirm" my design rather than a step to "challenge" it. The gap between our 1092N prediction and the 133N reality proved that a design is only as strong as its weakest unconsidered variable. By ignoring construction constraints like splice locations and glue reliability, the quality of the final product was compromised. This failure demonstrated that without physical verification, dangerous or life-threatening elements of a design may be unrecognized. I learned the importance of verification in increasing the Quality by uncovering hidden flaws before a design is put into use against the unpredictable variables of the physical world.

Now What?

Moving forward, I will prioritize verification as a mandatory feedback loop rather than a final check. Before promoting or finalizing a design, I will test the design in a low-stakes environment to identity any elements of the design that I missed. Then, iterate on any missed components iteratively until the final design verification is removed of dangerous and life-threatening elements. This ensures that my final design decisions are backed by demonstrated performance rather than just theoretical optimism, holding up to my personal value of high-quality engineering solutions.

Overall, the failure of my bridge taught me that an engineer's responsibility to Quality is only fulfilled when they have verified their design against the real implementation, not theoretical simulation.

My position of Engineering Design by the end of CIV102 Bridge

Engineering design is an iterative process of optimizing solutions through creativity and technical feasibility. It is the pursuit of the most efficient balance between material limits and structural requirements.

My Approach to Engineering Design (from crafting experience, Praxis I, CIV102 Bridge)

1. **Identify** the opportunity from experience.
2. **Frame** how solutions should theoretically work through quality research (from standards).
3. Evidence-based **Diverging and Converging iterations** to narrow down to a few designs with a focus on feasibility and constraints.
4. Create and use existing **prototypes** to compare through testing.
5. **Build** the product with care to increase the quality of the product.
6. **Integrate and test the solution in context** to see where the actual failure points are. If any circle failure points are identified, reiterate on the design again.

Annotations

By the end of the CIV102 Bridge, my position shifted to Dualism and Early Relativism. I realized there is no "perfect" bridge as everyone's bridge is different, but some resulted in similar performances. There is only a series of versions that perform differently based on where you choose to "sacrifice" mass to gain "reward" in strength. In addition, I recognize the importance of integrating and testing the solution in context to verify a solution from comparing our theoretical bridge with our physical bridge performance.

Praxis II: Exploring an opportunity for a community within the Greater Toronto Area (One-pager)

Project Context

Praxis II focuses on address an opportunity from a community in the Greater Toronto Area (GTA). Now the primary stakeholders are no longer about the community I am apart of, but stakeholders who I did not share similar lived experiences with.

For this project, I was in a team with Matthew Lam, Alex Han, and Parrot Xue as shown in Figure 17.

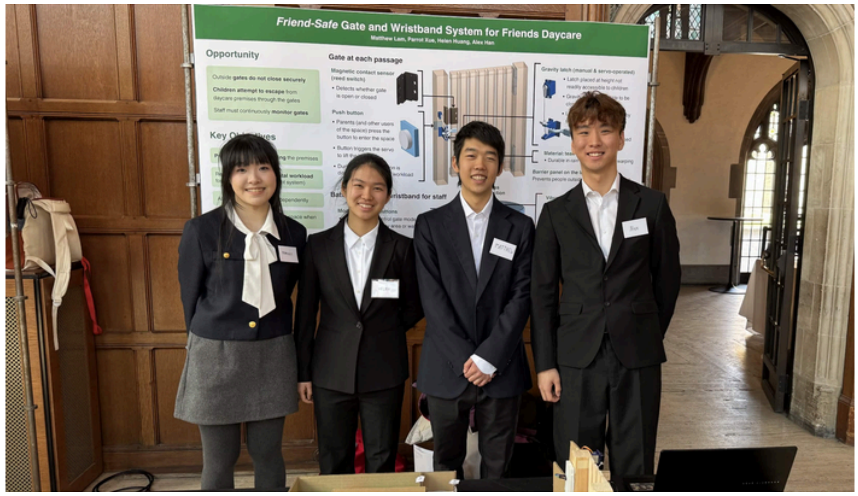

Figure 17: A photo of our team during Showcase.

Our team focused on a community called Friends Daycare for 2.5 to 5 year olds. Since the gates do not close securely, and children attempt to escape from the daycare premises through the gates, staff must continuously monitor the gates while children are outside. So, our opportunity is about preventing children from exiting daycare premises and reduce the physical and mental workload on staff while children are outside. In addition to these main needs, we must allow parents to enter the gates independently, and not interfere with other users use the space when the daycare is not occupied. Our solution to the opportunity is shown in Figure 18.

The Final Design

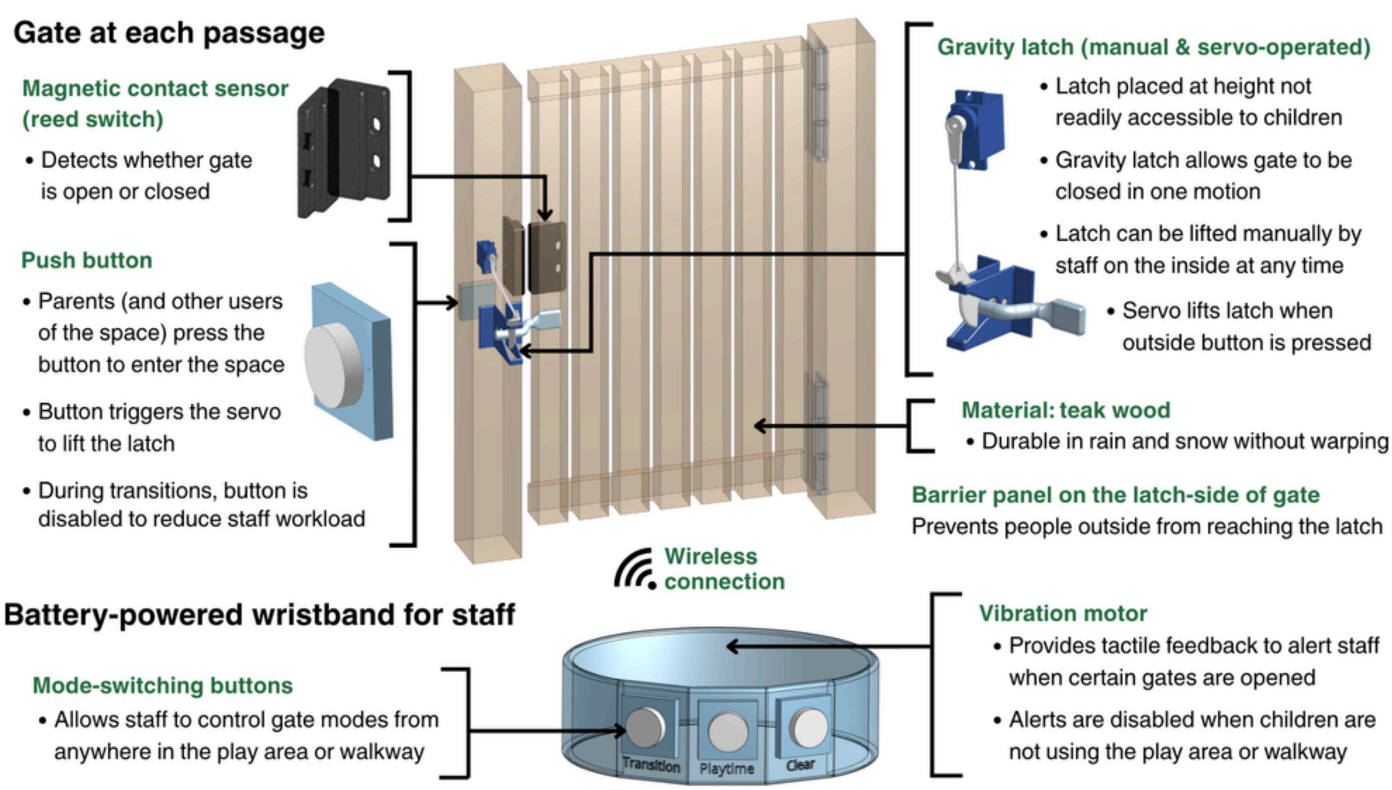

Figure 18: A section of the poster made for showcase made by Matthew Lam, Alex Han, Parrot Xue, and Helen Huang

Key Design Considerations

Manual and Electronic Push-Button Release for Targeted Access Gate Control

Process: To give staffs full access to opening the gate from the inside while having variable access from the outside, our team implemented a push-button on the outside of the gate. While this increases inconvenience for parents to pick up their children at anytime, it decreases staff burden. Since staff burden is prioritized over parent convenience, this push-button feature is chosen.

Final Design Solution: The final gate design has a push-button lock on the outside of the gate. This design reduces the mental burden on daycare staff by allowing them to lock the door to outsiders while they are busy transitioning the children between inside the daycare and the play area.

***Annotation**: This shows how my position evolved into from dualism to relativism. I realized that in a community with conflicting stakeholders, there is no "correct" answer because trade-offs must be made. Different prioritizations based on personal values and evidence leads to different, but not better solutions.*

Gravity Latch and Barrier Panels

Process: While using steelmanning to challenge our design, we noticed fixable and not fixable limitations to our design due to time constraints. For example, our design at that time did not prevent unauthorized reach-over of the fence to manually operate the gravity latch from the outside, so the barrier panels are added. However, the standard gravity latch requires pulling from the inside, while a pushing motion is suggested for emergencies; due to time constraints, this became a limitation in our design.

Final Design Solution: To address the security vulnerability where unauthorized users could reach over the gate to manually operate the latch, we integrated a barrier panel extension. This barrier panel is dimensioned using 95th-percentile reach data to ensure the latch remained inaccessible from the exterior.

***Annotation**: This decision marks shift in my definition of project completion from achieving technical perfection to accepting that there will be limitations and next steps. In Praxis I, I would have presented the gravity latch as the "perfect" answer. In Praxis II, I used Steelmanning to to find limitations within my design. This shift reflects my final position statement: engineering is an iterative process of minimizing limitation rather than achieving perfection. In addition, I learned to take more accountability in my designs by acknowledging their limitations for future iteration.*

Height of the Gravity Latch

Process: To determine the optimal latch height, I moved from aimless averaging a range of acceptable heights in Praxis I to considering a broader range of engineering constraints, including material sustainability and latch security.

Final Design Solution: We selected a height of 1548 mm for the latch. This height is chosen because it is beyond the reach of jumping 5 year old children while being reachable by almost all adults. Additionally, this latch height is on the lower side to reduce the overall gate height for material sustainability according to SDG 12: Responsible Consumption and Production.

***Annotation**: This decision represents a complete rejection of my Praxis I "Linear Thinking." In September, I used a Dualistic approach, simply averaging a range because I thought the middle was the "right" answer. In Praxis II, I used a Relativism approach to understand that different heights have different costs and benefits. I realized that the average of the available range latch height, which is 1678 mm, is not better than a 1548 mm latch height; it is worse when looking at it through a lens of material sustainability.*

CTMF 1: Stakeholder Mapping & Prioritization - Lec 14 ESC102 [2]

The purpose of this analysis is to explore how my approach to framing has evolved from straightforward self-centered stakeholder analysis to balancing value conflicts among different stakeholders. In Praxis I, I treated the framing of stakeholders as a search for objective truths that needed no compromises. However, during Praxis II, I recognized that engineering involves making difficult choices between competing stakeholder needs. Through describing, interpreting, and reflecting on this observation, it highlights my progression from Dualistic thinking to Relativist thinking of taking accountability for value-prioritization of stakeholders.

What?

In our final design, we chose to include push button feature that allow parents to enter at certain times; although this is not the best for parent convenience, it plays a role in reducing staff mental and physical burden. For the Friends Daycare, my team and I identified five stakeholder groups for our childcare safety gate: our design team, staff, children, parents, and nearby communities. Through repeated team discussions, we decided to set staff and children as our primary stakeholders as they interact with the system the most as shown in Figure 19. We set the parents and out communities as secondary stakeholders. This prioritization of stakeholders helped us make decision like the push button feature. For the push button, we intentionally prioritize staff needs, such as reducing staff burden during the busy transition times, and sacrifice parents' needs, such as parental convenience for entering whenever they want.

ORIGINAL RFP

5.1 Primary Stakeholders: Staff

The day care staff are the primary stakeholders, as they supervise the children's daily activities and are the direct users and enforcers of any design solution implemented. They interact with the gates continuously, particularly during transition periods, such as arrival and outdoor play (see Appendix C1). The solution would ultimately ease their supervision burden.

5.2 Secondary Stakeholders: Children

The children can be considered to be part of the environment and experience the direct safety consequences of the gate system, but they do not control its operation. Within the 2.5–5-year age range, exploratory behaviors such as climbing, crawling, and latch manipulation are expected [7]. This creates numerous safety considerations affecting children's safety and supervision conditions.

5.3 Tertiary Stakeholders: Parents and other building users (church, student organizations, etc) Parents interact with the gate system during drop-off and pick-up periods, and their actions can affect system reliability, such as gates often being left partially unlatched. Parents prioritize reassurance of child safety and smooth entry and exit processes, particularly during high-traffic periods when they may be carrying children or belongings (see Appendix C1).

OUR REORDERING

Primary Stakeholders: Staff

The day care staff are the primary stakeholders, as they supervise the children's daily activities and are the direct users and enforcers of any design solution implemented. They interact with the gates continuously, particularly during transition periods, such as arrival and outdoor play (see Appendix C1). The solution would ultimately ease their supervision burden.

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Secondary Stakeholders: Parents and other building users (church, student organizations, etc) Parents interact with the gate system during drop-off and pick-up periods, and their actions can affect system reliability, such as gates often being left partially unlatched. Parents prioritize reassurance of child safety and smooth entry and exit processes, particularly during high-traffic periods when they may be carrying children or belongings (see Appendix C1).

Figure 19: My team's alteration of the stakeholder prioritization from the original RFP (on the left) to the current framing (on the right).

So What?

This event represents my transition into relativism, where I recognize that there is no “perfect” solution, there are just designs differences based on the specific prioritization and trade-offs an engineer chooses to make. In Praxis I, I frame the stakeholder need as if all needs of all stakeholders can be prioritized without sacrifice. In Praxis II, we mapped out stakeholder need where we found a conflict of interest. Then, we intentionally prioritize certain stakeholder needs based on my framing to make decisions, such as the push button feature where the framing helps me accept a trade-off: inconvenience for parents in exchange for reduced burden on staff. Additionally, I also taking accountability for my design decisions by having an intentional and value-driven justification for each choice. This analysis demonstrates that a high-quality frame is not one that satisfies everyone, but one that acknowledges and deals with value conflict. It shows I have moved from a position of dualistic phase of finding the right answer to the relativism stage of defending a specific design based on stakeholder prioritization.

Now What?

Moving forward, I will use Stakeholder Mapping to identify conflicts in the design process. Then, using my teams values to make interpretations and act on what we believe is the most important to prioritize certain stakeholder needs.

Overall, this shows my shift from dualism and relativism mindset as I started viewing stakeholders a system of competing values.

CTMF 2: Steelmanning - Lec 7 ESC101 [1]

The purpose of this analysis is to explore how my definition of project completion shifted from achieving technical perfection to acknowledging that it is about doing as much as possible within the given constraints and taking accountability for a design's limitations. In my early position, I believed a design was only "finished" when all elements were performing "correctly." However, by using steelmanning to repeatedly challenge our design concept, I realized that all designs possess limitations; completion is about acknowledging these limitations, not removing them. Through describing, interpreting, and reflecting on this observation, it highlights my progression from seeking for a "correct" solution to seeking for an improved solution with acknowledgment for its limitations.

What?

My team applied Steelmanning to our gravity latch concept by testing extreme edge cases. While the latch was designed to be operated only from the inside, we challenged this by identifying that individuals could potentially reach over the gate to operate it. This critique led to the development of a barrier panel requirement, as shown in Figure 20, strengthening our concept. However, Steelmanning also revealed limitations that could not be resolved within our time constraints, such as emergency evacuation risks. We found that a standard gravity latch requires pulling the gate inward, which creates a crushing hazard if a crowd gathers during an emergency. Identifying this through Steelmanning allowed us to acknowledge and take accountability for this design limitation.

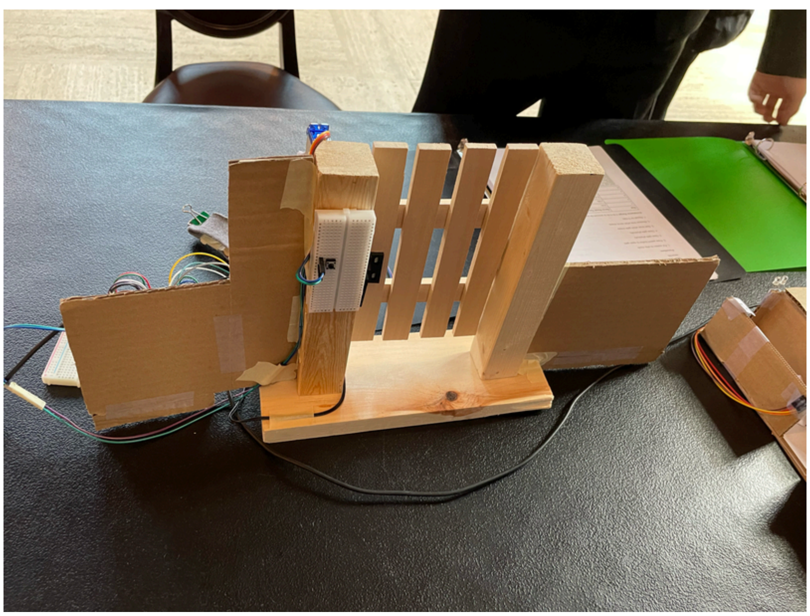

Figure 20: Cardboard pieces used to model the barrier panels added by Matthew Lam.

So What?

This event marks a change in how I define the end of the design process; I moved from seeking for "perfection" from a dualistic mindset to seeking for improvement with accountability for limitations from a relativism mindset. I previously believed that if a design had limitations, it wasn't finished. Steelmanning helped me accept that while some limitations are addressed, others must be acknowledged within given constraints. This shifted my goal in engineering design from making a "correct" design to making one that improves the lived experience of the community. This analysis demonstrates an enhancement in my accountability; steelmanning helped me realize that as an engineering designer, I must know, not be blind to, the limitations in my proposed solutions.

Now What?

Moving forward, I will use Steelmanning to identify the limitations within my designs. Instead of trying to present a perfect solution, I will provide an improved solution while taking accountability for the design limitations. This ensures that I am delivering higher quality improvements to the community while upholding the professional responsibility required to manage a design’s real-world limitations.

Overall, this event marks a shift in my definition of project completion from achieving technical perfection to doing as much as possible within the given constraints and taking accountability for a design's limitations.

CTMF 3: Pugh Chart - Lec 28 ESC101 [1]

The purpose of this analysis is to explore how I evolved from aimless averaging to intentional, multi-criteria decision-making. In Praxis I, I calculated the average to avoid the responsibility of prioritizing stakeholder needs as described in CTMF 1 of Praxis I in this portfolio. However, during the design of our childcare safety gate, I utilized a Pugh Chart to evaluate and justify the height we chose based on stakeholders prioritization and our team's values. Through describing, interpreting, and reflecting on this observation, it highlights my progression from intuitive averaging to evidence-based prioritization when making design decisions.

What?

To determine the gravity latch height, I moved away from aimless averaging to a value-based selection with a pugh chart. I identified a research-backed range of 1548 mm to 1808 mm. Instead of using the average, I used a Pugh Chart to compare three specific increments: 1548 mm represented by 1500–1600 mm, 1650 mm represented by 1600–1700 mm, and 1808 mm represented by 1700–1800 mm, as shown in Figure 21. The evaluation centered the barrier panels and sustainability; since the higher the latch, the taller the gate has to be to satisfy the barrier panels height requirement, which increases material use. Ultimately, I selected the 1548 mm to satisfy our barrier panel requirement while maximizing resource efficiency in alignment with SDG 12: Responsible Consumption and Production.

	1500mm - 1600mm	**1600mm - 1700mm**	**1700mm - 1800mm**
Effectiveness in preventing children from reaching	0	0	0
Effectiveness in allowing adults to reach	0	0	0
Material sustainability	0	-1	-1

Figure 21: A pugh chart to evaluate the optimal height the gravity latch should be places based on the three requirements and evaluation criteria that my team believe is more important.

So What?

This process represents the direct application of the lessons I learned in Praxis as I used requirements and evaluation criteria to find gravity latch height that matches the stakeholder needs and my team values instead of aimless averaging. The Pugh Chart helped make the benefits and drawbacks of each height clear for comparison where calculating the average does not. Overall, I learned that engineering design is not found in the middle ground between the needs of different stakeholders as I believed in Praxis I. Instead, engineering design is about being able to collect evidence to justify and take accountability for the design I propose. Additionally, I realized that my value of quality is upheld when I use systematic tools, like the pugh chart, to handle decisions rather than defaulting to a mathematical average that may not optimal for stakeholders.

Now What?

Moving forward, I will use Pugh Charts as a method to converge on concepts backed up by evidence to increase the quality and take accountability of my designs. Using these converging tools to consider stakeholder needs and personal values will help me prevent the aimless averaging that occurred in my earlier projects. This ensures that the final design choices I make are intentional choices that can be defended with needs of the stakeholders.

This CTMF serves as a parallel comparison to the problem I identified in my Praxis I analysis. It shows my evolution as an engineering designer as I learn to justify my design decision with more evidence.

My Position of Engineering Design by the end of Praxis I

Engineering design is an iterative process of refining solutions through creativity and technical feasibility. It is not a search for perfection, but a commitment to a defensible solution that minimizes system gaps. As an engineering design student, I take accountability for the trade-offs between stakeholder needs and for the limitations due to the physical constraints of the project.

My Approach to Engineering Design (from crafting experience, Praxis I and II)

1. **Iterative Opportunity Framing** based on the lived experience of the community and personal interpretations of it.
2. **Stakeholder Mapping and Prioritization** by identifying the stakeholders involved and prioritising certain values and needs.
3. **Frame** how solutions should theoretically work through quality research (from standards).
4. **Evidence-based Diverging and Converging** iterations to narrow down to a few designs with a focus on feasibility and constraints.
5. Create and use existing **prototypes** to compare through testing.
6. **Build** the product with care to increase the quality of the product.
7. **Integrate and test the solution in context** to see where the actual failure points are. If any circle failure points are identified, reiterate on the design again.

Annotations
Over the course of my first year, my engineering position underwent a shift from Dualism to Relatism. In the beginning of Praxis I, engineering design was about finding the "perfect" solution. By the end of Praxis II, I understand that engineering design involves prioritization of certain needs over others with evidence to find an improved solution. There are different design decisions based on the trade-offs made by different designers where each design has their strength and weaknesses. However, we can all take accountability for the design decisions and limitations in our designs.

References

[1] “ESC101H1 F LEC0101 20259:Praxis I,” Utoronto.ca, 2023. https://q.utoronto.ca/courses/411081/modules (accessed Apr. 12, 2026).

[2] “ESC102H1 S LEC0101 20261:Praxis II,” Utoronto.ca, 2023. https://q.utoronto.ca/courses/420731 (accessed Apr. 12, 2026).