Engineering Design: Innovation at the Intersection of Math and Science

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Introduction

In this paper, I define "**Engineering Design**" and **prove** that it is a result of my experiences. I also **apply** this proof to the real-world, showing my work as a student engineer is a consequence of my definition.

Definition of Engineering Design

- At its core, **engineering design is** the creative **application of** advanced knowledge in **math and science to innovate** and design solutions to real-world problems in ways that others cannot.
- It is a subset of engineering, which broadly includes the application of technical knowledge to better the world.
- Engineering design specifically focuses on the creative process of transforming theoretical knowledge into functional, real-world solutions.
- Engineering design leverages creativity to address constraints like size, cost, and compatibility, enhancing innovation by applying knowledge effectively.
- The central purpose of engineering design is to **improve** upon the existing state of the world, from the lens of scientific innovation.
- An engineer's primary responsibility lies in ensuring functionality, technical excellence, and innovation.

Proof

Proposition 1. *My definition of engineering design, as the creative application of advanced knowledge in math and science to solve real-world problems, is directly shaped by my cultural background, educational experiences, and personal reflections.*

Axioms

To begin the proof, we require axioms, statements which are true by definition. We have the following axioms to work with:

Axiom 1. *In my culture, children excelling in math and physics are often encouraged to pursue engineering, which is traditionally seen as a path to success. This cultural perspective played a significant role in my decision to study engineering.*

Axiom 2. *I performed best in math and physics during high school and thoroughly enjoyed both subjects.*

Axiom 3. *I began studying engineering without fully understanding what the profession entails. However, knowing it involved math and science—subjects I excelled at—I chose engineering.*

Axiom 4. *I believe that everyone's work should aim to better the world. My assumption that engineers contribute to societal progress was a key factor in my decision to pursue engineering.*

Lemmas

We prove the proposition using the following lemmas, derived from the axioms:

Lemma 1. *Engineering is the general use of math and science to better the world.*

Proof. By Axiom 3, I entered engineering without fully understanding its scope but knew it was grounded in math and physics (Axiom 1). My initial assumption, supported by Axiom 4, was that engineers contribute to societal progress by applying technical knowledge to solve problems. Using these axioms, I intrinsically defined **engineering** to be the general use of math and science to better the world. To define engineering design, we will expand on the foundational definition of engineering, as shown in the following lemma. □

Lemma 2. *Engineering design is the creative application of math and science to solve real-world problems within constraints.*

Proof. Engineering courses emphasize the practical application of theoretical knowledge, by imposing real-world constraints. For example, I was required to design a light, strong Matboard bridge in CIV102. Such constraints enhance engineering by requiring creative thinking beyond theoretical calculations to balance competing requirements. I designed a cheap, yet effective pendulum in PHY180, which required creative solutions to optimize performance within a limited budget. Figure 1 shows an example of this.

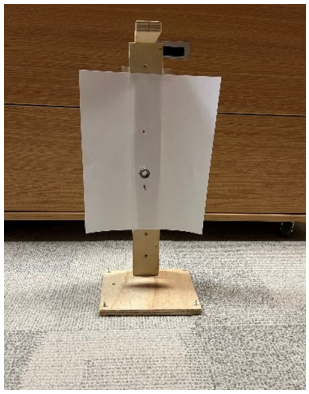

Figure 1: A bare-bones yet effective pendulum for PHY180's course project

Since this branch of engineering requires **designing** solutions, I intrinsically define it as **engineering design**. I derived my definition of engineering design primarily from my coursework, rather than from an absolute source of knowledge, as my understanding of meta-engineering concepts is limited (Axiom 3). Thus, engineering design, **to me**, is the creative application of math and science to solve real-world problems while addressing constraints. □

Lemma 3. *The purpose of engineering design is to make advancements in the world by leveraging engineering expertise and iteratively improving existing systems.*

Proof. By Axiom 4, I believe that everyone should strive to better the world through their work. This belief carries particular weight in a field like engineering, which I see as a field of privilege: accessible primarily to those with proficiency in math and science (Axiom 2). This unique expertise grants engineers the rare ability to solve problems that others cannot, making it essential for their work to **serve a higher purpose**. While it is true that not everyone shares this perspective, and therefore it may not belong in a universal definition of engineering design, I see it as a cornerstone of engineering in its most meaningful form. By embracing this principle as a personal definition, I will shape my daily practice to manifest this ideal. □

Validation of the Proposition

Through the axioms and lemmas presented, we have demonstrated how my definition of engineering design—"the creative application of advanced knowledge in math and science to innovate and solve real-world problems"—is directly shaped by my cultural background, educational experiences, and personal reflections. **Q.E.D.**

Application

Using the result derived in the previous section, I show how it applies to my day-to-day life as a student engineer.

Beliefs and Values in Engineering

Central to my definition of engineering design is the belief that engineers hold a privileged and responsible position due to their technical expertise. This belief motivated

me to pursue engineering, as I felt obligated to use my skills to contribute to societal progress. While I may not yet possess the tools for large-scale impact, I am cultivating foundational values that will guide my future contributions.

One of my core values is **accuracy**. Engineers wield significant power to shape the world, and even small errors can lead to catastrophic outcomes. I witnessed this first-hand: my CIV102 bridge collapsed due to the omission of a single failure case. I quickly realized the importance of sound engineering, and in future projects, such as in ESC180 coding assignments, I ensured all edge cases were accounted for to meet requirements and ensure reliability.

Another key value is **innovation**. To me, engineering design is about finding better solutions, not settling for the status quo. This drives me to explore alternative approaches to problems. During the PHY180 Pendulum Design, I considered multiple configurations to maximize performance within constraints, reflecting my commitment to solving problems in the most effective way possible.

By aligning my values with the responsibilities of engineering design, I aim to contribute meaningfully to societal progress. My focus on accuracy ensures that my solutions are reliable and technically sound, while my drive for innovation pushes me to explore new and better ways to solve complex problems.

Perception and Interpretation of Challenges

My perception of challenges in engineering design is shaped by the view that constraints are **opportunities** for creativity **rather than obstacles**. When approaching a problem, I interpret constraints as integral to the solution space. For example:

- In the CIV102 Matboard Bridge Project, dimensional limits and material properties were not viewed as restrictions but as design parameters that informed the final solution. This perception allowed me to explore innovative ways to optimize the bridge's performance while adhering to the constraints.
- In the MAT185 assignment, I interpreted the space constraint as an opportunity to practice brevity, developing more efficient proofs to meet the requirements

This mindset reflects my belief that addressing constraints is not only a practical necessity but also a **core aspect of engineering design** that fosters creativity and innovation.

Connecting to My Definition of Engineering Design

These **experiences** and **values** demonstrate how my approach as a student engineer aligns with my **definition of engineering design**. Engineering design is not just a theoretical construct but a **guiding philosophy** that informs my approach as a student engineer. Whether completing a homework assignment or designing a bridge, my work embodies the creative and practical application of math and science that defines engineering design.

Visual Representation

Figure 2 shows a visual representation of how my experiences lead to my definition of engineering design and how that influences my practice as an engineer.

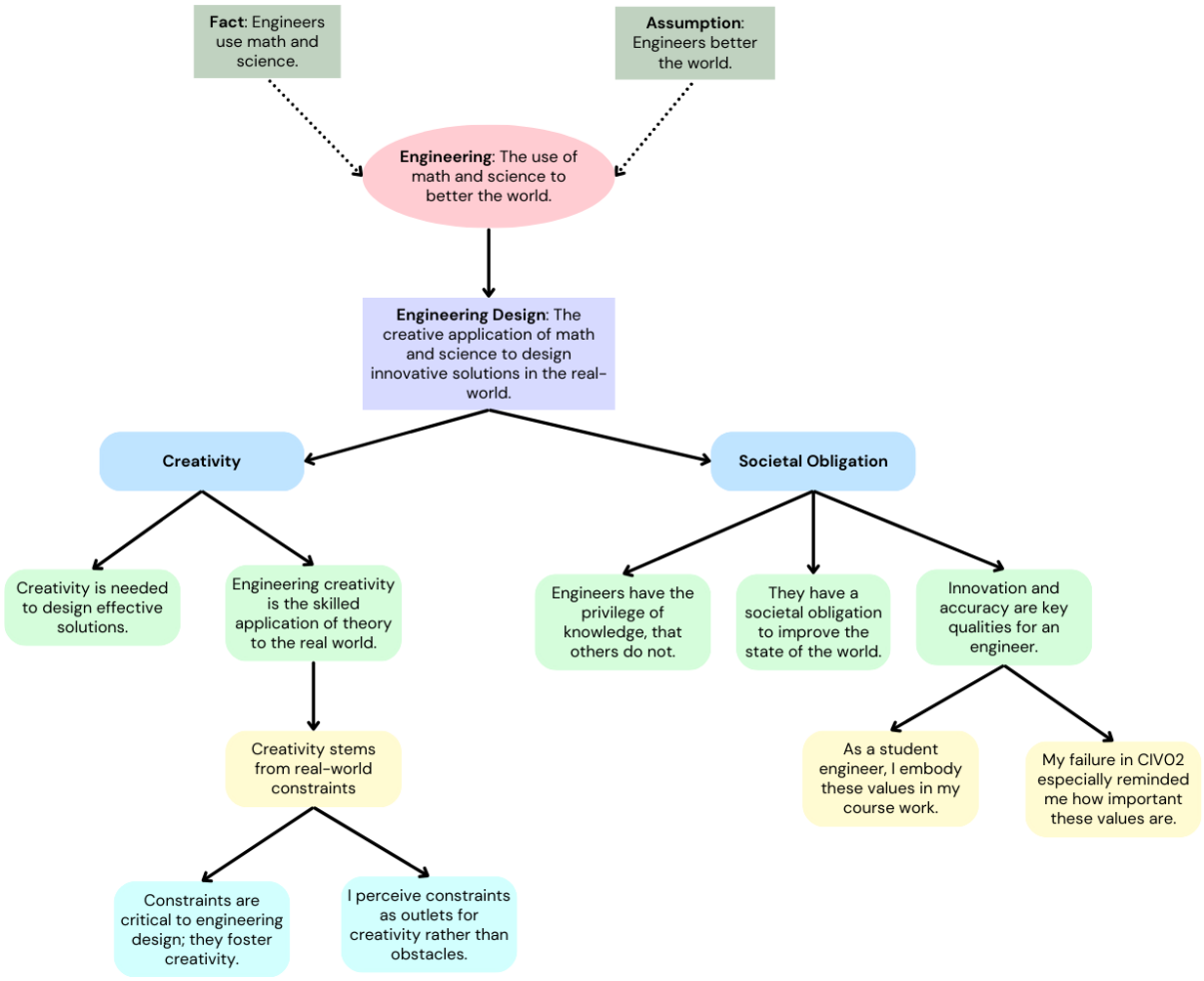

Figure 2: Flow-chart of my engineering design philosophy and its influence on my life