Praxis II - Student Engineering Handbook

ESC102 Final Assessment

J. Lefebvre

jayden.lefebvre@mail.utoronto.ca

Student Number: 1006861344

Engineering Science

Faculty of Applied Science and Engineering

University of Toronto

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Contents

1 Introduction

The purpose of this handbook is to document my learning and position as an engineer and designer at this point in my development. It will accomplish this by documenting my design products, and the tools/ models/frameworks I have used to achieve those, as well as reflecting on each in terms of their utility to future design work. In addition, this handbook documents my personal engineering design process as it stands currently.

This handbook is created in the hopes that it will be of some design assistance to future me. To navigate this document, refer to the Table of Contents.

2 Position

My approach to designing is best described as top-down: I consider myself a big-picture person, so when confronted with a problem, I am often able to see the larger solution before imagining its subcomponents. I have found that this is highly dependent on how related the problem is to both my existing design work as well as my interests; the closer, the more easily I can conceive a solution. In this way, so long as I am able to properly frame a problem and break it down into its component parameters (more on that in Process), the more easily, reliably, and rigorously I am able to diverge and converge on solution features.

Since the way I approach problems is "solution-first", that often puts me in an interesting position when it comes to teamwork. Often during the first team meeting after being presented a problem, I will present my potential solution, and encourage my team to play with the parameters conceptually. While this does accelerate the decision-making process and put me in a position of leadership I am comfortable with, this also means that some team members might be uncomfortable with sharing ideas non-tangential to the initially-proposed solution, reducing the overall scope of diverging. In my opinion, this is the ultimate design paradox: the wider the scope, the better you can diverge, but the less features and parameters are shared between designs, and thus it becomes very difficult to converge on one feature set on a detailed level. I also have certain biases when it comes to problem-solving. Since I have been working with technology (programming, electronics, etc.) creatively for most of my life, I am inclined to use it to develop solutions even if it means increasing the complexity. My interest in technology is one of the main reasons I decided to become an engineer.

One of the most interesting things I've learned since coming to EngSci last september has been the value of rigor. I've learned that despite being able to solve a problem, it is just as important to be able to show how you got there, and why each decision was made. This is especially true when it comes to open-source work, which I am passionate about, as it allows people to contribute to projects collaboratively and freely.

Finally, one of the first lectures of Praxis II asked the question: "Do you consider yourself as more of an engineering student or a student engineer?" This was thought-provoking for me, as although I have been academically successful for my entire life, it wasn't the learning that brought me joy; it was instead being able to apply what I've learned to a real-world problem that interested me. This has led me to focus more on projects, real-world problems, design teams, and startups in my first year than I had anticipated:

- Electronics Engineer w/ UofT Hyperloop Team, working with sensors, protocols, state machines
- Project Lead w/ UofT CloudClub, teaching other eng. students professional web dev. techniques, frameworks, and practices
- Founded UofT Agritech, developing an autonomous controlled-environment agriculture solution, going to compete in the NASA/CSA Deep Space Food Challenge

3 Products

3.1 Praxis I Personal Engineering Recommendation

This was my first attempt at engineering design. Since taking a number of research and writing composition courses in highschool, I had become accustomed to a certain style of writing. Although this writing style translated well into claim-argument form, I failed to meet some of the key targets of engineering design, including employing the tools and frameworks provided for comparative analysis of design candidates. The assessment of my performance reflected this.

METRICS, CRITERIA, AND CONSTRAINTS FOR OPTIMIZATION

Compliance with COVID-19 restrictions is measured by many metrics, primarily through the wearing of masks, proper sanitization procedures, and physical distancing [8]. In addition, as both Chestnut and St. Michael's College have outlined [6, 9], all self-service dining is replaced by "full-service" dining. Any solution **must** follow these **constraints**, considering their importance.

Financial feasibility for Providers is difficult to measure; however, considering that the cost of the meal plan has not changed in many years [6], it is safe to assume that this dollar figure represents a reasonable **baseline** for an income that makes both the old 'all-you-care-to-eat' meal plan and the current 'declining balance' model financially feasible.

Environmental friendliness in the context of food services is best measured by waste [5]. The model that produces the least waste would then be considered the most environmentally friendly. However, given the "boxed meal plan" [6] put in place in response to COVID-19 guidelines, this metric is useless; all meal plans would be required to produce effectively similar waste.

The most efficient metric for measuring affordability for students (and myself) is the total cost of the meal plan, and considering it has not changed in many years, and that under the old plan eating habits did not influence affordability, this number should be considered a baseline. In the case of the current 'declining balance' model, firsthand data collected allows us to compare average daily meal spending to the total allotted meal funds to measure long-term affordability.

Figure 1: An extract from my PER - note the distinct lack of tables or figures in the metrics section. Odd [1].

3.2 Praxis I Framing - Design Brief

This was my second attempt at engineering design, and I took the framing failures from the PER and applied new strategies to avoid those pitfalls. I had gained a more thorough understanding of the FDCR process. I was also able to apply my passions for both plants and technology towards this design brief, leading to a greater degree of personal investment, which I believe is key to good framing.

Weekly Required User-Plant Interaction Minutes - DO3	The lower the time requirement, the higher the score.	**N/A**
Container Footprint m^2 - DO3	**N/A**	**MUST** be able to be operated in any student living area (residence, house, apartment)
Cost CAD - DO2	The lower the cost, the higher the score.	**N/A**
Plant Compatibility Boolean - DO6	**N/A**	**MUST** be suitable to grow **ANY** houseplant with a space and form requirement appropriate to the candidate design

Figure 2: An extract from my framing sprint team's design brief - note the proper use of metrics, with corresponding units, etc. [2].

3.3 Praxis I Diverging - Candidate Design Parameterization

During this sprint, I began to form the basis for my personal engineering design process. Since the design brief provides both the necessary requirements/ constraints and broken down objectives, it became easy to anchor our diverging and establish a list of parameters from those two (respectively). This allowed us to use attribute listing and reverse brainstorming to develop a better understanding of the parameters, and generate new features based on them.

Step 1: Causing the problem	Step 2: Preventing the causes
Drinks that are too hot	- Cooling mechanism (e.g. ice) - Allow people to blow on it (open top) - Serve drinks only when acceptable temperature is reached??
Container retains heat too well (user cannot properly feel the drink's temperature)	- Use cheaper/less insulative material - Open top to allow hot air to escape
No indication of steam	- Transparent cup - Open top
No indication of how much drink is in the cup	- Transparent or semi-transparent cup - Transparent strip on the cup
Very wide spouts/openings	- Sippy cup (or adjustable spout) - Bottle (i.e. gatorade) - Cup cap (with small spout)
Not giving the user proper warning signs	- Baristas should give verbal warnings - Caution: Hot - Thermochromic paint - Thermometer

Figure 3: An extract from my diverging sprint team's Candidate Designs and Tools Critique, showing the use of design parameters in the context of reverse brainstorming [3].

3.4 Praxis I Converging - Design Critique and Categorization

During the converging sprint, I was able to expand my personal process to incorporate diverging in a way that matched the "parameterization" approach I had already developed. My converging sprint team found that the candidate designs generated during the previous sprint were hard to compare along the general metrics of success provided by the design brief. This was due to the function differences - each design approached the problem in a radically different way. However, there were some that could be grouped together along similar functions, and then compared within the category with derived metrics appropriate for that category's function. Once the categories were developed, a genetic algorithm was employed, pulling together feature assessment (Pugh chart), recombination (MORPH chart), and ultimate category candidate prototyping and comparison to develop one singular candidate from a highly diverse pool.

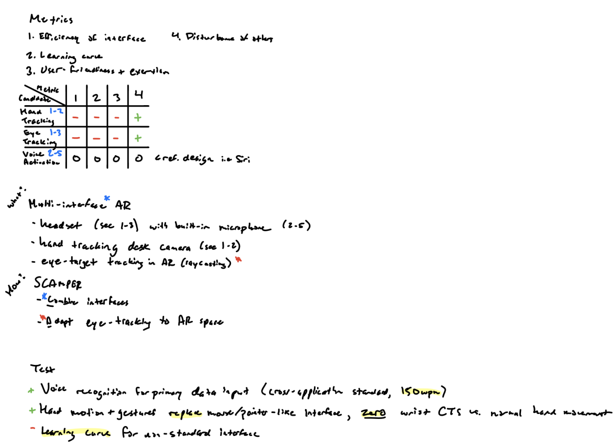


Figure 4: An extract from my converging sprint notes. Though slightly illegible, it shows the development of category metrics (top-left) and feature recombination (centre) [4].

3.5 Praxis II Control Flow Diagram

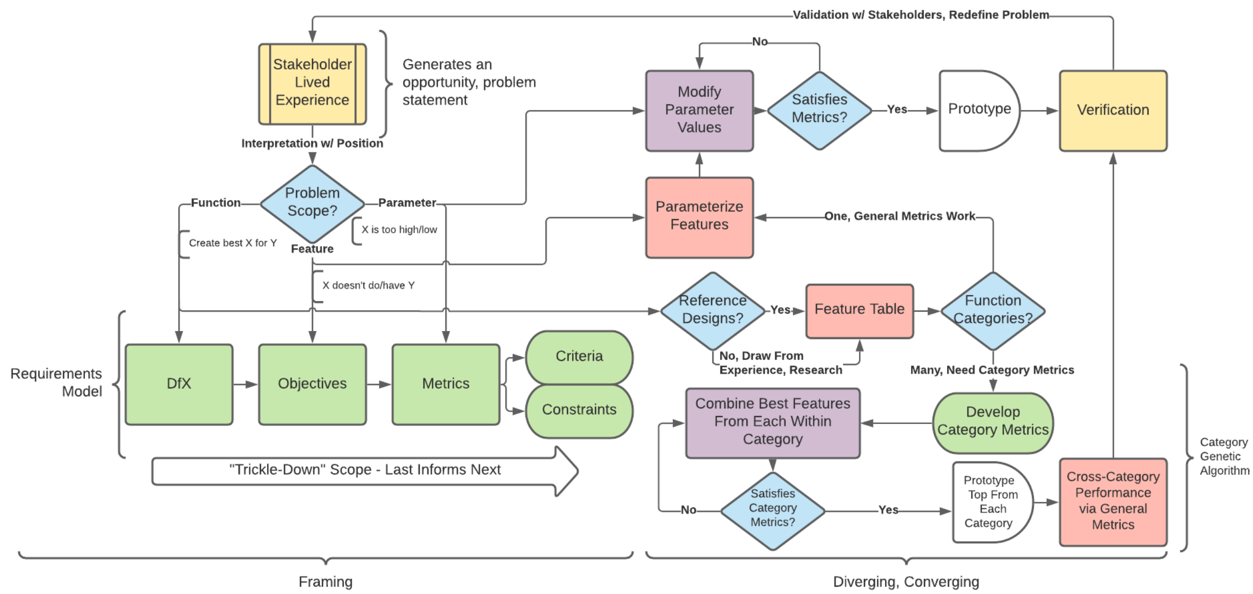
When developing prototypes that are meant to enact a certain process ("process prototypes"), it is often useful to lay out the process before any development occurs. This is especially true for technological prototypes, like programs. Starting from the most top-level "vision" of the prototype (some input produces some output) and breaking that down to the low-level "pseudocode" makes prototyping complex systems far easier. In essence, it is a framing process that leads directly to development, which is extremely useful in practice.

3.6 Praxis II Hardware Prototype

As mentioned in the position section, I have a certain bias towards technical prototypes due to my interest in the field and past experience. However, I find there is a huge amount of payoff in developing a genuinely applicable prototype that could legitimately be used to solve the problem (call it a "coarse solution") as compared to other prototypes (you know the ones, the cardboard-and-duct-tape ones). If I am able to develop a real solution, it feels like I've actually solved the problem and completed the engineering design process, as opposed to in Praxis I, where sprints were disjointed and never used the same topic twice.

4 Process

The way an opportunity is handled (where framing starts, how diverging/converging start) depend on the scope of the "problem statement" interpreted from the stakeholder's lived experience. This process is largely derived from the parameter optimization approach, and incorporates the category genetic algorithm, both derived from what I learned in Praxis I.



5 Tools, Models, and Frameworks

5.1 Attribute Listing

After framing the problem down to the metric scope, the desired functions (and thus features) of successful candidate designs can be listed. In this context, they are called attributes, and parameters are built directly off of these: parameters control the "level" (more or less) of an attribute's contribution to the ultimate design.

Step 1: Objective/DfX	Step 2: Consider Value of Attribute	Step 3: Modify Attribute
Recyclability	+ Good for the environment, carbon footprint, etc. - Maybe more expensive to mass-produce - May limit types of materials available	- Materials (i.e. paper cups) - Label/separate recyclable and non-recyclable parts of design

Figure 5: An example of attribute listing performed in the Praxis I diverging sprint [3].

By using a "first principles" approach to divergence based solely on the requirements model (as opposed to abstract brainstorming), my teams were able to explore the entire breadth of the opportunity. However, this tool also has the potential to be restrictive. For group members who might prefer abstract imagination, their ideas did not necessarily fit this model.

The straightforwardness and linearity of this tool allows high efficient during the diverging process. There is also an increased sense of accomplishment, more so than when using other, less straightforward tools.

This tool is particularly useful at the start of diverging, as it helps to lay out the basis for a set of potential candidate designs. You can then adapt and branch off in order to develop more unique and imaginative ideas.

5.2 Reverse Brainstorming

The goal of reverse brainstorming is to change how a problem statement is worded from how it can be solved to how it can be caused. After different ways to cause the problem are identified, design functions that address each cause are proposed and potential features combined in order to target multiple factors in one candidate design.

Overall, reverse brainstorming is a helpful tool to use after doing some initial brainstorming,

Step 1: Causing the Problem (Scalding)	Step 2: Preventing the Causes
Large drink opening	• Adjustable aperture • Sippy cup • Gatorade bottle opening
Not knowing how far to tilt the cup	• Transparent cup
Overly hot temperatures	• Cooling mechanisms • Temperature regulating machines (serve drink at optimal drinking temperature)

Figure 6: An example of reverse brainstorming performed in the Praxis I diverging sprint [3].

specifically in situations where the scope of an opportunity may stifle creativity or lead to anchoring. Reverse brainstorming is also useful for organizing candidate designs based on their function and for combining features of different candidate designs to target a variety of contributing factors related to the opportunity. Reverse brainstorming is also useful to expand scope by realize that there are many other factors that might be contributing to the problem, other than those initially identified during framing.

5.3 Pugh Chart

5.4 MORPH Chart

References

[1] J. Lefebvre, “Praxis i personal engineering recommendation.”

[2] ——, “Praxis i framing sprint design brief.”

[3] ——, “Praxis i diverging sprint candidate designs and tools critique.”

[4] ——, “Praxis i converging sprint design critique.”