

GNG2101

Design Project Progress Update

GROUP F1.3

Submitted by:

Alex Novac

Anjali Chalayil Sreekumar

Armand Guigma

Emily Way, 300299495

Jennifer Campbell

January 19, 2025

University of Ottawa

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List of Acronyms and Glossary

Table 1. Acronyms

Acronym	Definition

Table 2. Glossary

Term	Acronym	Definition

Introduction

The goal of this project is to design a one-handed, foldable cane that is lightweight, easy to use, and capable of being quickly folded and unfolded with one hand. This report works to identify the problem and plan the design process. After identifying the core user needs and requirements, the problem definition is states. The report outlines the design specifications, including metrics and benchmarking, and provides a functional analysis of various design concepts. Overall, the document will provide a comprehensive overview of the design process, from the problem definition to concept evaluation, eventually leading to a design solution that balances functionality, ease of use, and portability.

2. Sustainability Report and DFX

2.1 Sustainability report

Table 3: Sustainability Constraints

Triple Bottom Line	Positive Impact	Negative Impact
Economic	Jobs creation	High initial investments
	Affordable manufacturing cost	Competitive market limits profitability
	Revenue from recycling used product into raw material	Marketing expenses.
Environmental	Use of recyclable materials	carbon emissions during manufacturing

	Lightweight and compactable design minimizes the fuel usage for transportation	e-waste is produced if an electric design is used
	Long-lasting design reduces the frequency of replacements	Raw material extraction
Social	Enhances accessibility	Limited global availability
	Community awareness	Unique designs are harder to repair
	Increased user safety	Obsolescence

Economic:

On the positive side, the project promotes job creation in manufacturing, assembly, and distribution, while affordable production costs make it accessible to a broader market. Innovative features can drive increased sales and position the product competitively. However, the project requires a high initial investment in production facilities and equipment, and profitability may be constrained by intense market competition. Additionally, marketing expenses to build brand awareness could further impact the financial outlook, requiring strategic resource allocation to ensure economic sustainability.

Environmental:

Using recyclable materials can significantly reduce the waste output of a product. For a large manufacturing company, using recyclable materials would help the product reach the necessary environmental regulations and reduce long-term material costs if they can be reused. On a smaller scale, sourcing leftover materials from the MakerSpace reduces waste and cost for this project.

Additionally a compact and lightweight cane design allows for more units to be shipped per container, which reduces fuel consumption. This allows major companies to ship their products while lowering their carbon footprint.

A durable cane reduces waste and materials by minimizing the need for frequent replacements, decreasing the environmental impact over time. However, manufacturing processes like 3D printing, injection molding, or metal machining contribute to carbon emissions. Using carbon offset programs and renewable energy can lower carbon emissions. Additionally, the made-to-order aspect of this project supports a smaller-scale, precise manufacturing process, making it easier to optimize emissions at every stage. Incorporating electrical components like motors or batteries will lead to the contribution of e-waste, especially if recycling programs for electronics are not well-established in production regions. Proper disposal methods, using recyclable electrical components, and sticking to industry standards is needed to lower e-waste. Finally,

extracting materials like materials or polymers can harm ecosystems and contribute to pollution. Large companies must ensure materials are ethically and sustainably sourced. For example, a woodworking company may commit to planting a certain number of trees per year to account for their materials extraction. To design the cane, this team should use the recycled materials from the MakerSpace to reduce the negative environmental impact and showcase sustainable practices on a smaller scale.

Social

The cane is designed to improve mobility and independence for individuals with disabilities or mobility challenges, helping them to navigate their environments safely and confidently. This allows users to participate in social, professional, and recreational activities that may otherwise be inaccessible. Additionally, the cane can raise community awareness about hidden disabilities. Many individuals with mobility challenges, like the client, face issues where others fail to recognize their need for accommodations, such as priority seating on public transportation. By incorporating subtle visual cues into the cane's design-such as distinct colours, patterns, or symbols it can serve as an indicator of a user's disability. This could promote greater empathy and cooperation for the public to provide accommodation. The cane's design focuses on enhancing user safety by providing physical support. This will lower the risk of injury and provide peace of mind for users and their surroundings. This positive impact extends beyond physical safety, contributing to greater confidence and improved quality of life. While the cane addresses accessibility challenges, its global availability may be restricted by factors such as production costs, availability of materials, or distribution networks. These limitations may make the product inaccessible to those in lower-income or remote areas. Ensuring affordability and widespread availability is crucial to maximizing its societal impact. Furthermore, the personalized and unconventional design will complicate repairs, leading to higher costs for repairs, particularly if specialized tools, materials, or expertise are required. Lastly, as technology evolves, the cane may face obsolescence, leaving older designs less desirable. This could lead to dissatisfaction among users who cannot access frequency upgrades. Additionally, if the cane is not designed with replaceable components, the users are forced to replace the entire product instead of upgrading specific parts.

2.2 LCA report

Product that you are evaluating: Single-hand folding cane

Objective and Scope

The objective of this LCA report is to evaluate the environmental performance of the single-handed folding cane designed with sustainability and efficiency in mind. The goal is to produce a cane using recyclable and lightweight materials, ensuring an environmentally friendly design while maintaining functionality and durability. This report will assess the cradle-to-cradle life cycle stages of the cane, including raw material sourcing, production, transportation, use, and end-of-life management, to identify opportunities for improvement and promote sustainable practices.

Define the steps of the cycle which will be covered: Determine the stage(s) of the product life cycle you are analyzing. Write a brief description here:

The stages of the product life cycle that will be analyzed in the report follow a cradle-to-cradle scope, offering an examination of the product's journey through the chosen lifecycle. We will begin by evaluating the processing and production of the product, which includes the transformation of raw materials into usable parts and their assembly. Next, we will examine transportation, focusing on the logistics and environmental impacts of moving the materials and product across the supply chain. The retail and use are the next phase that will be explored, examining the distribution and sale of the cane, including the packaging and accessibility in retail/other platforms. Finally, we have the end-of-life stage which encompasses recycling, waste management, and the product's potential reintegration into the production cycle.

Define the aspect of sustainability that will be studied: Circle the area that will be studied

Environmental

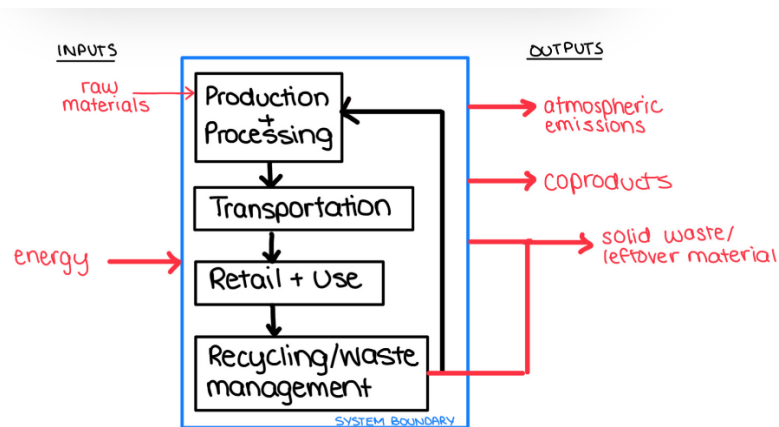
Economic

Social

Define the duration of the study: Determine the length of time you will consider for doing your study:

The length of time that we will consider for this product will be a timeframe of 5 years.

Conceptual limit of the system: Draw a diagram with your specific product and its system boundaries. Includes system inputs and outputs.



Inventory analysis

Step 1 Acquiring materials:

Type of raw material	Points
Bauxite	1
Silica	1
Total points	2

Step 2 Material processing:

Plastics or metals in the product	Points
Aluminum	1
Silicon	1
Total points	2

Step 3 Manufacturing:

Different parts and pieces of the product	Points
Body of the cane	1
Handle	1
Base	1

Total points	3
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Step 4 Packaging:

Packaging	Points
None	0
Paper or cardboard packaging only	5
Plastic packaging only	15
Plastic and cardboard packaging	10
Styrofoam or rubber packaging	15
Instruction sheets included separately in packaging	5
Total points	0

Step 5 Transport:

Transport	Points
Yes, by plane, truck or boat	15
None	1
Total points	1

Step 6 Using the product:

Product Usage	Points
The product can be used once	15
The product can be used for 6-12 months	12
The product can be used for 2 years	11.25
The product can be used for 5 years	10
The product can be used for more than 10 years	5
Total points	11.25

Step 7 Disposal:

Parts of the product made from plastics or metals	Points
The product must be discarded	15
Some materials in the product can be recycled	5
All products and materials in the product can be recycled	0
Total points	5

Impact assessment

Total points	34.25
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Interpretation and improvement

1. What could you change about your product to improve its environmental impact? Describe your improvements here.

The greatest contributors to the product's environmental impact are the materials used to manufacture it. The process of turning bauxite into aluminum is one that relies on hydroelectric dams that have been known to negatively harm the surrounding environment. Using only recycled aluminum, or a more environmentally friendly material to make the body of the cane would mitigate this impact. The use of silicone presents a similar issue. The processing of silica to silicone emits a significant amount of carbon dioxide, presenting a negative environmental impact. This could also be mitigated by finding an alternative material that can be recycled, and that has a more environmentally friendly manufacturing process. Another top contributor to the environmental impact is the product's lifespan. The cane can last approximately two years with regular use, then can only be partially recycled. Focusing on more sustainable materials that will last longer than 2 years can mitigate the negative environmental impacts once the product has reached the end of its lifespan.

2. Look at your inventory analysis above. Recalculate your score if you were to use the improvements you just described. Has your score changed? By how much?

Using the above improvements, the total points decrease by 6.25. Assuming an increase in the product lifespan from 2 years to 5 years, the total points will decrease by 1.25, then by only using recyclable materials the points will decrease by 5 points.

3. What should you do to further reduce the environmental impact of your product?

After making changes to the material and the product lifespan, the manufacturing process could be examined to further reduce the environmental impact of the product. Using machinery of any sort, from the transportation used to obtain the materials, to manufacturing them into a working cane contributes negatively to the environment in some form or another. Using more sustainable travel methods, as well as ensuring that canes are made to order, only using machinery when necessary will reduce such an impact.

2.3 Design for X

Following the client meeting and their statements, our team brought out multiple factors potentially impacting the focus of the cane design.

1) Design for Safety

- a. Objective: Minimize potential dangers related to the use of the cane (particularly reducing risks of injury)
- b. Metrics: Maximum acceptable load (N), Safety factor (dimensionless)
- c. Constraints: Cane supports a minimum load of 100kg with a safety factor of 1.5. Material choice for the tip ensures a non-slip surface.
- d. Design criteria:
 - i. Elastic (non plastic) deformation under expected loads
 - ii. Non-slip (ex. Rubber) material for the handle and tip
 - iii. Edges rounded to prevent injuries

2) Design for Manufacturing

- a. Objective: Design an easy to produce cane with minimal cost and complexity
- b. Metrics: Manufacturing cost(\$/unit). Production time (h/unit)
- c. Constraints:
 - i. Assuming the tools are provided by the Makerspace, materials selection allows production within a budget of 75\$
 - ii. Assembly requires no more than 3 steps
- d. Design criteria:
 - i. Use of off-the-shelf components where possible
 - ii. Design for automated fabrication process (ex.: 3D printing, laser-cutting). This might be difficult in the context of this project but works as an example

- 3) Design for Usability (and portability as a sub aspect)
 - a. Objective: Enhance user experience by ensuring the cane is easy to use, carry, and store
 - b. Metrics: weight (kg), foldability and compact storage dimension (cm)
 - c. Constraints: weight is below 0.8kg, folded length is less than 30% of initial length
 - d. Design criteria:
 - i. Ergonomic handle is designed for prolonged use
 - ii. Lightweight but durable materials such as aluminum or carbon fiber
 - iii. Foldable cane with a secure locking mechanism
- 4) Design for Speed
 - a. Objective: Minimize the time required to bring the product to the market
 - b. Metrics: Time to finish the ideation process. Time to complete the final prototype.
 - c. Constraints: Choice of concept will be made in the next 2 weeks. Final prototype created and tested by the design day
 - d. Design Criteria:
 - i. Rapid prototyping using 3D printing to receive feedback fast.
 - ii. Design multiple pieces at the same time in order to shorten the design process
- 5) Design for Reliability
 - a. Objective: Ensure consistency and durability of the product throughout its life
 - b. Metrics: Product lifespan in years, number of successful uses before failure (cycles)
 - c. Constraints: The cane maintains functionality for a minimum of 5 years and withstands 1000 successful uses without failure
 - d. Design criteria: Use of materials resistant to wear and tear. Test the product in real-world conditions (loading and environmental tests).

3. Problem Definition, Concept Development, and Project Plan

3.1 Client Needs

Table 4: Client Needs

#	NEED	Imp.
1	The cane is lightweight	4
2	The cane is useable with only one hand	5
3	The cane assembles and disassembles quickly	4
4	The cane assembles and disassembles using one hand	5
5	The cane comes with carrying pouch to store it	3
6	The cane resembles a walking stick	3
7	The grip of the cane allows for hand extension	3
8	The cane supports the user's weight	4

9	The cane is compatible with client's active lifestyle	4
10	The cane indicates that the user is disabled	2

***1 being the least important, 5 being the most important**

Table 5: Client Knowns and Unknowns

Knowns	Unknowns
<ul style="list-style-type: none"> - Client has a very active lifestyle (competitive cyclist, goes to the gym frequently, is a student, etc.) - Client uses public transit and requires a free hand to board safely - Client uses the dominant side of their body to walk - Client requires use of their hand while using the cane - Client prefers a walking stick as opposed to a cane - Client has health issues that limit mobility - Client's hand is better at extending than grasping - Client has difficulties carrying a backpack, requires somewhere to put the cane when not in use - Client does not place a lot of weight on the cane - Client has an invisible disability, would like some form of identification that will inform people so they can sit in the accessible seating on the bus 	<ul style="list-style-type: none"> - Client's level of mobility and dexterity in dominant hand - Client's grip and hand strength in dominant hand - Client's level of balance and how much support they require - Client's weight (to establish how much weight the cane should be able to withstand) - Client's dominant hand - Client's colour preferences for the cane

3.2 Problem definition

Our client needs a one-handed foldable walking cane that prioritizes ease of use, portability, and a lightweight design. The device must open and close quickly with one hand, provide support without compromising strength, and include a convenient storage solution for when the cane is not in use. The cane should feature an ergonomic grip that minimizes the need for excessive grasping, ensuring comfort during use.

3.3 Provide a list of need inspired metrics with appropriate units and conduct benchmarking on similar solutions (can satisfy some or all needs). Provide descriptions and pictures when possible. - ALEX

3.4. Develop a set of target specifications (both ideal and marginally acceptable values). Provide reasons for your choices.

Concept development

Project plan

Add a screenshot of your gantt chart.

Conclusions

The design process for the one-handed, foldable cane has highlighted several key challenges in creating a practical mobility aid. Through analysis of the client meeting notes, it has become clear that the most important needs are usability and portability. While significant progress has been made in developing design specifications and analyzing possible solutions, there is a lot more brainstorming and client input needed. It will be essential to continue testing the design based on client feedback to address any concerns regarding real-world use. The implication of this project extends beyond the design solution, as the process offers valuable insights into user-centered design processes and the importance of incorporating accessibility features into everyday products.

Bibliography

Insert your list of references here.