GNG2101

Design Project Progress Update

Team A04-BA3, Prototype Pros

Submitted by:

Akarsh Gharge, 300113523

Youssef Sokri, 300368462

Alejandro Arce De Rojas, STUDENT NUMBER

Abdul Based Abdul Rahim, 300379200

Salim Aissaoui, STUDENT NUMBER

September 29, 2024

University of Ottawa

1. Table of Contents

[Project Deliverable Report Instructions i](#_Toc176011212)

[Table of Contents ii](#_Toc176011213)

[List of Figures iii](#_Toc176011214)

[List of Tables iv](#_Toc176011215)

[List of Acronyms and Glossary v](#_Toc176011216)

[1 Introduction 1](#_Toc176011217)

[2 Sustainability Report and DFX 2](#_Toc176011218)

[2.1 Sustainability report 2](#_Toc176011219)

[2.2 Design for X 2](#_Toc176011220)

[3 Problem Definition, Concept Development, and Project Plan 3](#_Toc176011221)

[3.1 Problem definition 3](#_Toc176011222)

[3.2 Concept development 3](#_Toc176011223)

[3.3 Project plan 3](#_Toc176011224)

[4 Detailed Design and BOM 4](#_Toc176011225)

[4.1 Detailed design 4](#_Toc176011226)

[4.2 BOM 4](#_Toc176011227)

[4.3 Project plan update 4](#_Toc176011228)

[5 Conclusions 5](#_Toc176011229)

[6 Bibliography 6](#_Toc176011230)

1. List of Figures

**No table of figures entries found.**

[Table 1. Acronyms iv](#_Toc177722235)

[Table 2. Glossary iv](#_Toc177722236)

1. List of Acronyms and Glossary

Table 1. Acronyms

|  |  |
| --- | --- |
| **Acronym** | **Definition** |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

Table 2. Glossary

|  |  |  |
| --- | --- | --- |
| **Term** | **Acronym** | **Definition** |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

# Introduction

This design report outlines the process and justifications behind the development of a bathroom assistant device for a client with arthrogryposis who has limited hand strength and limb mobility. The objective of our project is to design, and protype a feasible solution for the requirements we gather from the client. Our solution will aim to meet all functional and non-functional requirements of the user while working within our project budget and other constraints related to the problem domain.

We will be updating this document throughout the process on any key decisions being made. This report will document each phase of the design as well as other design related information and will act as a useful resource for both internal reference throughout the design process and any future design teams working in a similar problem space. This report will provide a comprehensive summary of the design methods employed, the key solution features, and will ensure that the solution meets the project objectives.

# Sustainability Report and DFX

## Sustainability report

### Triple bottom Line

Table 3. Triple Bottom Line Table

|  |  |  |
| --- | --- | --- |
| Triple Bottom Line | Positive Impact | Negative Impact |
| Economic | Affordable for the average family in Canada | Since the design does not exist yet, there will be added costs to fund prototypes |
| Creation of a potentially new market | Will require higher costs to purchase parts from other manufacturers instead of making them |
|  |  |
| Environmental | Able to be reused for years to come without the need to be thrown out | Would use rubber seals to stop water (not very environmentally friendly) |
| Most metal is reused from other sources | Shipping the parts will leave a carbon footprint |
|  |  |
| Social | Safer alternative than attempting to strain yourself | May be considered aesthetically unpleasant to some |
| Promotes self-sufficiency and confidence | Long project timeline for a proposal of high interest |
| Allows greater accessibility for the differently abled in washrooms | Can be cumbersome for out of school uses |

### Life Cycle Assessment

1. **Objective and Scope**

Goal:   
This LCA will focus on assessing the environmental impact of a mobility assistance tool for a client with limited flexibility and hand strength throughout it's life cycle.

Functional Unit:  
1 mobility assistance device

System Boundary:   
Our system boundaries will be all stages of the product’s life cycle from material extraction to end-of-life disposal.

Assumptions:

* The device will be made with recycled materials as much as possible
* One device will have a 3 year lifespan
* The devices end of life will be considered when the user cannot use it anymore and will have the options of further recycling the materials, or disposing of the device in the garbage

1. Inventory Analysis

Material Sourcing:

* Raw Material: Estimated 150 grams of recycled metal, and 150 grams of recycled plastic
* Environmental Impacts:
  + Emissions from vehicles used in plastic and metal collection process
  + Air and water pollution from the recycling process
  + Environmental impacts related to the energy generation process for the recycling plant
  + Chemical and other waste byproducts resulting from the recycling process
  + Emissions from transportation of materials from recycling plant to our production location

Production:

* Environmental Impacts:
  + Emissions from production plant dependent on power source
  + Geographical impact on local wildlife due to productions plant
  + Any other chemical or regular byproducts or waster products because of manufacturing
  + Emissions resulting from transportation from production facility to sales locations

Use Phase:

* Energy Use: None, uses human power

End-Of-Life:

* Disposal Considerations:
  + Further recycling of materials at time of disposal will help reduce need for new material production in terms of plastic, and mining efforts for metals
  + Disposing of the device in a garbage landfill will have a longer lasting impact on the local environment by contributing to pollution

1. Impact Assessment

Materials Sourcing:

* Greenhouse gas emissions from transportation efforts will be dependent on distances between points of interest like the recycling plant and the manufacturing plant
* Other environmental impacts from the recycling plant will be dependent on the technology being used at the recycling plant, and the byproduct disposal practices

Production:

* Greenhouse gas emissions from transportation efforts will be dependent on distances between the manufacturing plant and the various points of sale
* Other environmental impacts from the manufacturing plant will be dependent on the technology being used at the recycling plant, and the byproduct disposal practices

Use Phase:

* The use phase impact is significantly less than the other sections of the life cycle as the product will be human powered and not have any other energy consumption

End-of-Life:

* Environmental impacts will be dependent on the method of disposal
* Recycling will have a lower impact on the environment in terms of reducing the need for new plastic creation and reducing the need to mine metal but could have other impacts resulting from the recycling process and the technology used
* Disposal in a landfill will have an impact over thousands of years as plastic does not biodegrade

1. Interpretation

* The product’s impact on the environment is primarily expected to be at its highest during the manufacturing stage. There will be considerable emissions during the mining process as well as during the molding of plastic and metals. Since we intend to use plastic, considering bioplastics, which are more renewable than traditional polymers, can reduce the impact. We should also avoid the popular method of injection molding, which uses a considerable 0.9 – 1.6 kWh/kg of energy, one of the highest of any molding method.
* We can also expect considerable impacts during the transportation phase, as most of the parts will need to be shipped by a third party for the design. There will likely be multiple points of contact which results in emissions from delivery trucks as well as planes.
* The impact during the product’s lifespan will depend on it being motorized or not. Many current bathroom aids require the use of some sort of motor. A motorized device will need to be powered to be used. The client intends to use the product multiple times a day, which will require a considerable amount of energy from non-renewable sources. If we further assume that it uses batteries, the impact from the end of its life will also be increased substantially, as it can leak hazardous waste. Minimizing the use of batteries and relying on mechanical systems will allow use to reduce CO2 emissions during its use and EOL.
* In any case, plastic can take up to 500 years to decompose in the environment, depending on the amount and type used. Metals can be re-processed or recycled in most cases, contrary to plastic. Our end of life is represented by about 50% percent repurposing and another 50% incineration and landfilling, depending on the products used. We should consider using recyclable metals and even plastics, in order to reduce the impact of the EOL.

## Design for X

1. **Design for Reuse:**  
   **Application:** Create an easy-to-use product that the user can easily put on and remove to support her throughout the day.  
   **Importance:** A product that is easy to put on and remove ensures that the client will be able to take advantage of the solution with minimal affect to her day-to-day routine, leading to higher benefit for the user, a happier user experience, and a higher likelihood of permanent adoption of the product into the user’s routine.  
   **Criteria and Constraints:**

* 4-6 uses daily; ~50 uses weekly
* Help user repeatedly use up and down pulling motion for pants
* Adaptable to multiple years of use

1. **Design for Portability:**  
   **Application:** Design a product that is easy to transport between locations.  
   **Importance:** A product that is easy for the user to take between home, school, and any other locations will ensure that they will be able to use it wherever they are without too much hassle, leading to consistent benefit for the user regardless of location, and a happier user experience.  
   **Criteria and Constraints:**

* 8 hours of carrying a day
* No more than 7 pounds, below 5 pounds is preferred
* Able to fit inside of the client’s school backpack
* Can be used in any public washroom setting

1. **Design for Quality:**   
   **Application:** Design a product that works reliably.  
   **Importance:** A product that is of higher quality ensures that the client will feel comfortable using it and does not depreciate in value quickly. This leads to the customer feeling more comfortable in using the product and ensures value for the cost.  
   **Criteria and Constraints:**

* No itchy Materials
* Smooth and unrigid
* Durable materials
* Rust and mold resistant to prevent damage
* Flexible

1. **Design for Safety:**   
   **Application:** Design a product that does not harm the user or their environment.  
   **Importance:** A product that is safe will ensure that the user can continue to use the product without having to take additional risks. It ensures that the user remains safe during use. Designing the product for safety also includes protection from damages to the user’s property, which would lead to extra costs.  
   **Criteria and Constraints:**

* Must not inflict pain upon the user
* Cannot pinch the user or have tight bindings
* Does not cause the user to strain themselves beyond their limits

1. **Design for Functionality:**   
   **Application:** Design a product that serves its purpose in a consistent fashion.  
   **Importance:** A product that is functional and fulfills many needs ensures that the client can find a solution to their issue no matter what situation may arise. This leads to a longer usable lifespan, a better user experience, and less need to find additional products to satisfy the user, which in turn will cost them.  
   **Criteria and Constraints:**

* Must last at least 6 months without a major malfunction
* Pull a skirt or pants of varying lengths up and down Able to avoid getting caught on external objects
* Able to effectively perform objective regardless of how the clothing is currently positioned

# Problem Definition, Concept Development, and Project Plan

## 3.1 Problem Definition

### Client Needs

|  |  |  |
| --- | --- | --- |
| **Reference #** | **Priority** | **Interpreted Client Need** |
| 1 | 2 | Device should be compact enough to fit in a backpack |
| 2 | 4 | Device must be portable; able to be used in any setting |
| 3 | 5 | Device should be able to clamp onto clothing |
| 4 | 4 | Device must be light enough for user to carry daily |
| 5 | 3 | Device connection points and interaction points must be adjustable |
| 6 | 3 | Device is waterproof |
| 7 | 3 | Device is easy to maintain |
| 8 | 2 | Device can adjust to the client’s growth |
| 9 | 5 | Device must assist in stretching pants waist out to a larger circumference |
| 10 | 5 | Device can endure many uses |
| 11 | 5 | Device can raise and lower pants waistband |
| 12 | 4 | Device must be user-friendly and easy to put on |
| 13 | 5 | Device must require minimal assistance to use |
| 14 | 5 | Device movement mechanism’s must require low grip strength to operate (up to 5lbs) |
| 15 | 3 | Device must be made of comfortable materials |
| 16 | 1 | Device must be visually appealing |
| 17 | 5 | Device is safe to operate by anyone |
| 18 | 2 | Device needs to be unrestrictive |
| 19 | 4 | Device needs to be easy to remove |
| 20 | 5 | Device needs to have failsafe components for movable mechanisms |

### Problem Statement

**Problem:** Our client has a physical condition that reduces grip strength and flexibility which is impacting her ability to raise and lower her pants when she is using the restroom.   
**Impact:** This issue is restricting our client’s ability to be independent when she is using the restroom, which she has expressed causes her discomfort.  
**Background Information:** The problem can be split into two distinct sub-systems. The first is a problem created by a lack of grip strength when the user is trying to reach around the back to stretch her pants around her rear. The next component of the problem is created by mobility issue when pulling up her pants.   
**Ideal Outcome:** Both sub-system problems exist independently of each other and a complete solution would address both issues to help complete the entire process of raising and lowering the client’s pants.

### Established Metrics

1. Ease of Use + Effectiveness

* Time taken to wear and take off the device (seconds) - Measures the time it takes for the user to pull up and down their pants using the device manufactured

1. Clamping Mechanism

* Force Required (Newtons) - the amount of force required to be exerted in order to successfully use the contraption and complete the task

1. Ergonomics

* User Comfort (Qualitative Rating from 1-5) - Measures the comfort level of the device measured by the user after each use,
* May also take into account certain problems such as body strain, awkwardness in positioning and material quality

1. Safety

* Pinch points (Number of points) - number of areas where client body and positions get caught
* Stability, slippage + fall risk (1-5 rating) - how well the device and the user remain stable

1. Durability + Reusability

* Lifespan (Years of use) - How long the contraption can be operated effectively without breaking or requiring repairs
* Number of uses Daily (number of uses) - Takes into account the number of times the device can be used and if it can be re used effectively

1. Portability

* Weight(lbs) - measures the weight of the object to see how easily the client can life and move the device
* Size(cm^3) - measures the size of the object to understand what it may or may not be able to fit into and if it can be transported easily

### Benchmarking

Table 4. Benchmarking Table

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Selection Criteria | Weight | [EzyUps Dressing Aid](https://www.ezyups.com/ezyups-dressing-aid) | [Vivi Zipper Pull and Button Hook Dressing Aid](https://www.amazon.ca/Vivi-Dresser-Dressing-Assistance-Shoelaces/dp/B004UG1TWI) | [Clip and Pull Dressing Aid](https://www.amazon.ca/Dressing-Wearing-Trousers-Pulling-Adaptive/dp/B08V53BK6Q) | [Wooden Dressing Stick](https://www.amazon.com/Everyday-Medical-Supply-Dressing-Stick/dp/B00366DT8K/ref=sr_1_9?dib=eyJ2IjoiMSJ9.hJj9dHcut-CK4yHHPP5OfOeG1bwJgAhw6x2PIaWjB7qB0lF9HPYOCR1dd7CyDO6WcrRrClSSSn7QNLNzKO-PHmJHV0nH4VpAQftl9VXQQJGp4QNqTcoJtOWHopCI59GefyAQBHgqKuw3fFCrKmHejBRKNRjiQif0gCxdlMHbqvWsjIGn3190B37wF6vA--jF.q0zV-jCkmW7sf8n544Uyg-ii9LbF9uZ9arQFALBXGOY&dib_tag=se&keywords=grabber&qid=1727625559&s=hpc&sr=1-9) |
| Reference Number |  | 1 | 2 | 3 | 4 |
| Weight | 0.05 | 200 g | 136 g | 70 g | 136 g |
| Clamping mechanism | 0.1 | Slides inside of clothing and hooks | Simple hook for button and zippers | Manual clips | Push and Pull hook |
| Safety | 0.3 | Does allow users to reach behind and does not fully attach as a clamp (fail-safe) | Small hook could easily get caught; device does not help with reaching around | Manual clipping does not help users reach difficult areas and has no fail-safe | Simple concept with longer reach for harder areas. Clamping relies on grip and will not get stuck easily. |
| Ease of use | 0.2 | Simple slide in and pull out | Users must reach towards desired hook location. Does not make pulling from anywhere but the front easier. | Users must reach towards desired clamp location and insert clips | Grab rear end of pants with hand clamp and pull as normal. |
| Size | 0.05 | 50 x 5 x 5 cm | 12.7 x 3.81 x 1.27 cm | 115 cm (Adjustable and foldable strap) | 68.6cm |
| Reusability | 0.1 | Simple with no mechanisms so it is unlikely to break after extended use. Will not grow very much with the user. | Small parts can easily break if misused | Strap is very durable and adjustable to growth | Hand grabber can easily wear down after extended use |
| Effectiveness | 0.2 | Easily reaches any desired location, hooks on and helps to stretch pant waist. | Only effective when there is a button or a hook which is not always the case | Only effective when users can reach around their body to clamp desired locations. Does not help with stretching, only pulling | Reaches any desired area and helps in pulling down pants. Requires some level of grip strength. |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Selection Criteria | Weight | Device 1 | Device 2 | Device 3 | Device 4 |
| Weight | 0.05 | 3 | 1 | 5 | 1 |
| Clamping mechanism | 0.1 | 2 | 5 | 1 | 4 |
| Safety | 0.3 | 5 | 3 | 3 | 3 |
| Ease of use | 0.2 | 4 | 2 | 1 | 4 |
| Size | 0.05 | 3 | 5 | 5 | 2 |
| Reusability | 0.1 | 4 | 2 | 5 | 2 |
| Effectiveness | 0.2 | 4 | 1 | 2 | 3 |
| TOTAL | 1 | 4 | 2.5 | 2.6 | 3.05 |

### Target Specifications

**Dimensions:**

* The product will weigh less than 5 lbs.
* The product circumference will be adjustable to a max of 5 inches larger than the clients current waist size

**Materials:**

* The materials used will be flexible cloth materials wherever the product comes in contact with the client’s skin
* Components that are not in direct contact with the client’s skin will be made from rust-resistant materials like 3D printed plastics

**Ergonomics:**

* All handles will be made from 3D printed plastics and be ergonomically friendly

**Aesthetics:**

* The product will attempt to use the clients favorite color purple as much as possible

## Concept development

## Project plan

Add a screenshot of your gantt chart.

# Detailed Design and BOM

## Detailed design

## BOM

## Project plan update

Add a screenshot of your gantt chart.

# Conclusions

Summarize your lessons learned and your work related to your project. Discuss any outstanding issues or implications for the project.

# Bibliography

Insert your list of references here.