GNG2101

Dressing Tree Project

Accessibility Hookers, Group 3.3

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December 1, 2023

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Table 1. Acronyms

Acronym	Definition
AC Power Source	An AC (Alternating Current) power source is a device that provides electrical energy in the form of alternating current.
Anchors	To be a point of security and sturdiness.
Dressing Tree	An assistive device designed to help individuals with disabilities dress independently.
Electrical	This term is related to electricity, a form of energy resulting from the existence of charged particles such as electrons or protons. It involves the study and application of electromagnetism, electronics, and electricity.
Mechanical	This term refers to something related to machinery or tools. It involves the design, construction, and use of machines or mechanical systems.

Table 2. Terms

Term	Acronym	Definition
Accessibility Hookers	AH	Our team's names
Alternating Current	AC	A type of power source
Bill of Materials	BOM	Breakdown of supplies and costs

1 Introduction

This report presents a comprehensive exploration of an innovative solution designed to empower children with limited fine mobility. Our primary focus is to enable these individuals to complete the everyday task of dressing independently thereby fostering their confidence and self-reliance. A key aspect of our project is the development of an adjustable device that accommodates the changing needs of a growing child, ensuring long-term usability and relevance. The document is structured to provide a detailed insight into our business model, design process, and the value proposition of our product. Through this endeavor, we aim not only to assist our direct clients but also to extend these benefits to a broader spectrum of users facing similar mobility challenges. Our approach underscores the importance of adaptability and user-centric design in creating impactful solutions. Throughout the report, the discussion of how our final prototype was developed and tested. The business and economic aspects were considered if the product was to be launched on the market.

2 Business Model Canvas and DFX

2.1.1 Value Proposition

Allow children with limited limb mobility to complete everyday tasks independently and improve confidence. We want to remind ourselves with the value proposition above because our goal is to help the client become more independent by completing an everyday, like dressing herself. Our device must be adjustable vertically because we are working with a growing child. As she grows, shifting this aspect of her life to an independent activity will give her more privacy and increase confidence levels. This can apply to different customer dealing with similar conditions or difficulties with mobility.

2.1.2 Business Model Canvas

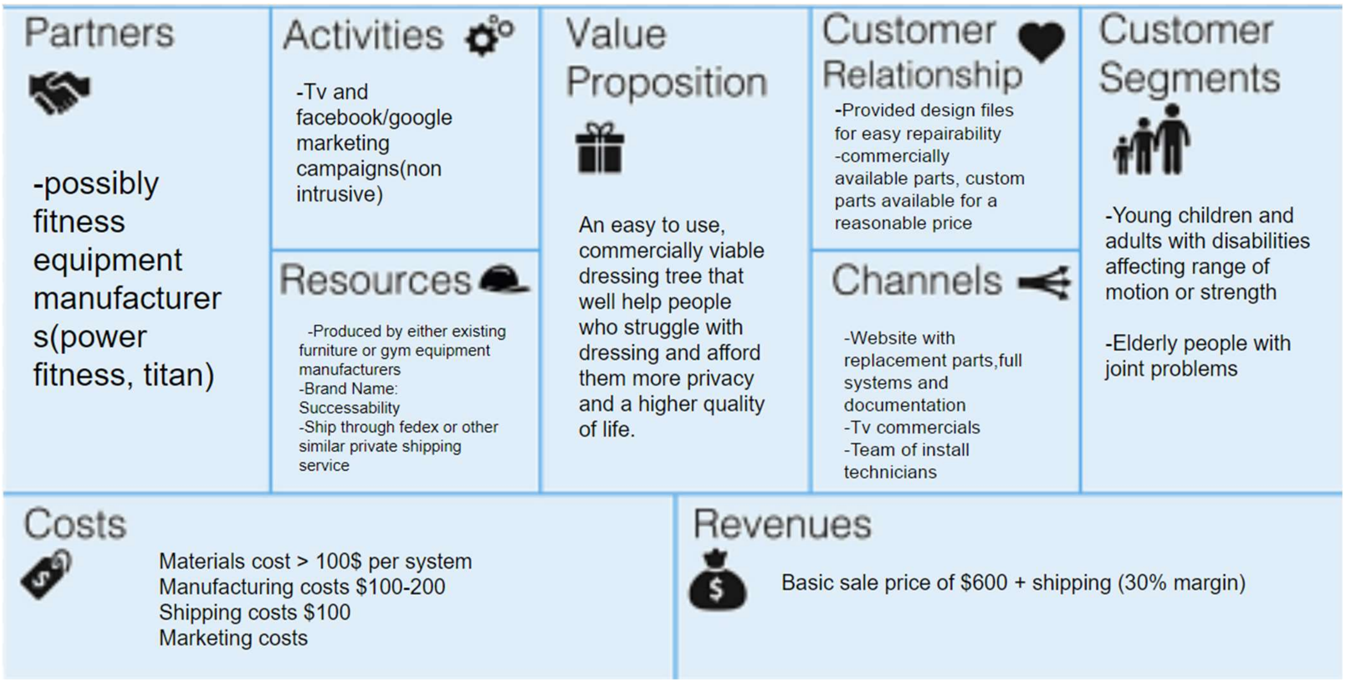


Figure 1. Business Model Canvas

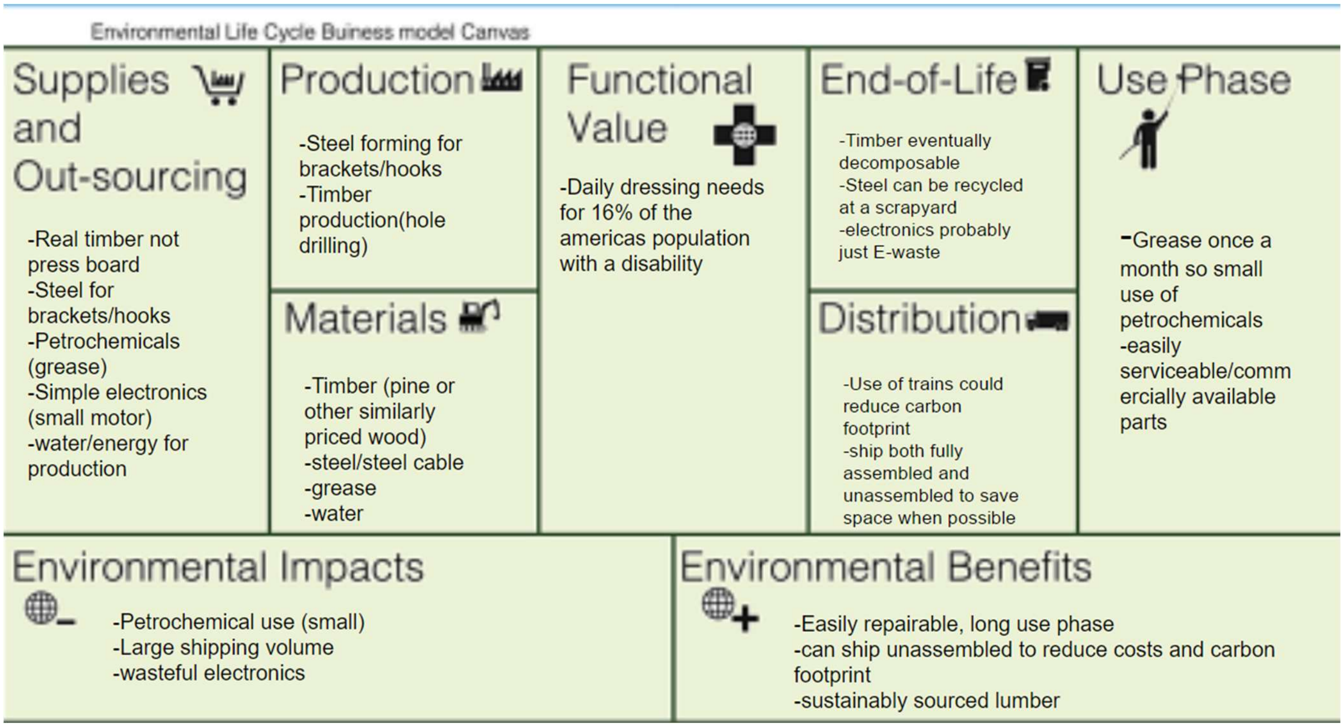


Figure 2. Environmental Business Model Canvas

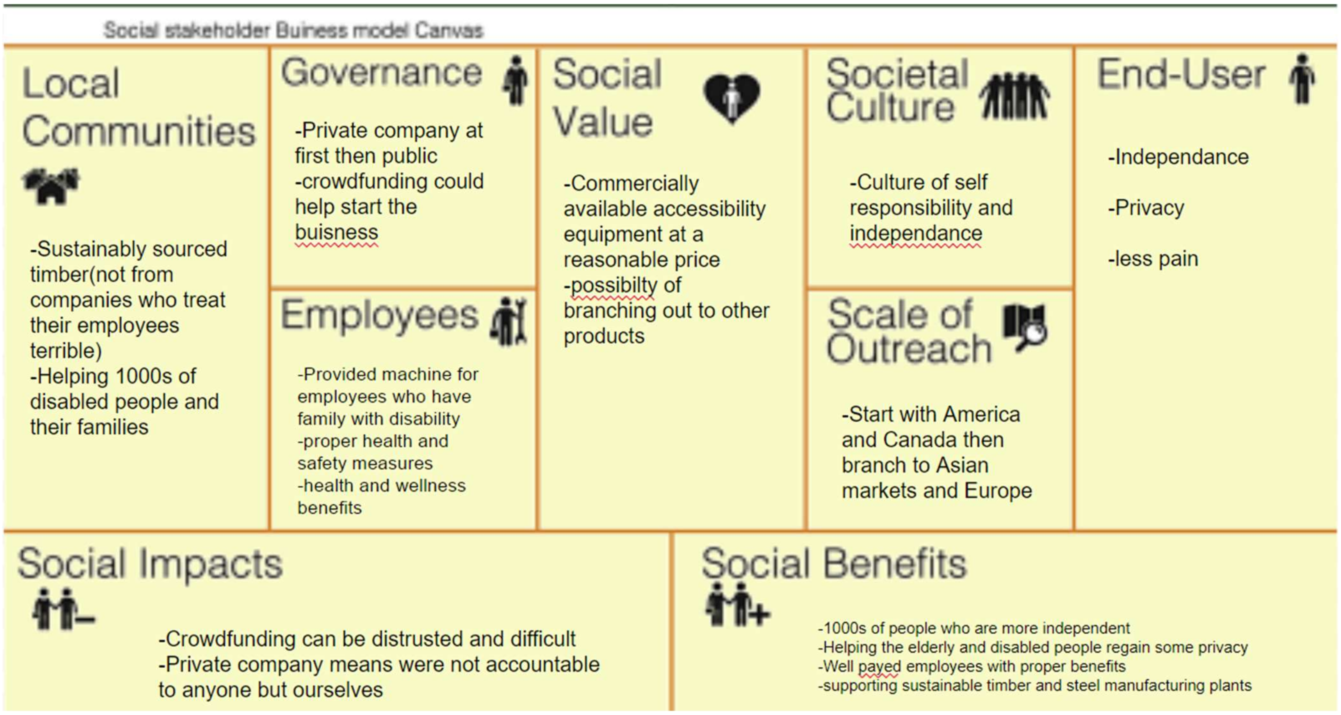


Figure 3. Social Business Model Canvas

https://docs.google.com/drawings/d/1COYdzJhq-L7b0B6T2S10XcOBZAb5k5omI1AaSqQuR34/edit?usp=sharing

- We assumed that we would be able to partner with fitness companies to provide a stable and secure structure for which to build our system around. Fitness companies such as Power Fitness and Titan have invested in research into safe and secure lifting cages, like our device. This partnership would not only grant us access to the technology implemented for safety, repairability and strength in lifting cages; we would also be increasing our ecological sustainability by skipping the extensive material research and waste. We assumed we could partner with doctors and occupational therapists to receive valuable feedback on what changes could be made to better serve the customer.

- We assumed the owner of the dressing tree will be able to perform light maintenance to extend the dressing tree's life and its components.
- We assumed we would have a physical space to design, manufacture and extensively test our products and interact with customers and clients in local hospitals, occupational therapist offices and clinics. These interactions would help Successability tailor each dressing tree to the exact needs of the client.

2.1.3 Sustainability Report

Social Impact

In the scope of this project, the social aspect of sustainability consists of designing products while taking into account the well-being of the community impacted. In our project, one way to include the community that we wish to serve in the process of popularizing our products and bettering it, we will collaborate with existing structures such as the Amputee Society of Ottawa. This structure in particular has multiple experiences helping and fostering a safe environment for amputees, which allows them to share their observations about common shortcomings in products that are made for this demographic. The actors in Amputee Society of Ottawa have a better understanding of specific conditions that we are targeting, therefore are best positioned to offer feedback that we will take into account to make our product better. Furthermore, as the point of contact between our company and the amputee community of Ottawa, the society will facilitate the broadcast of our company, our products and their availability at a reasonable price.

Another capital component of social sustainability is the treatment of our employees. We aim to create a diverse and welcoming workspace that will allow them to innovate, discuss and create products with the conviction that we represent our core values, which include inclusivity, acceptance and non-judgment towards the community we serve.

On the other hand, our product's creation can have a negative social impact on our targeted community. It is common knowledge that the amputee community faces discrimination and stigmatization due to their condition. Such treatment often affects their mental health and creates a feeling of being “powerless” in many individuals. The use of a dressing tree, although practical and a source of independence, could be seen as something that sets them even more apart from individuals who do not have their condition, and therefore do not require any assistance with getting dressed every day. Therefore, it is important to us as a company to focus on the gain of autonomy that our clients will receive, and to raise awareness in the non-amputee community to possibly combat the stigmatization given to those who do need assistance.

2.1.4 Environmental Impact

In our prototype, the environmental aspect of sustainability is shown in the creation of a prototype made of a recyclable and biodegradable material that doesn’t threaten the environment it will be in, whether that be the present or the future. In the past deliverable, we mentioned that the frame of the dressing tree will be made of wood while the hooks, a negligible volume, will be made from metal. We have chosen wood as the main material because it is natural, sustainable, and renewable. In other words, not only is wood found in nature, it can grow back with time when collected responsibility from trees. Furthermore, wood can intake substantial amounts of carbon, contributing to a more carbon-free environment around it.

The negative impact of our product on the environment is the use of wood that involves cutting down trees, which indirectly affects the quantity of carbon being absorbed before the tree is cut down. Although we make a point of using as little wood as possible to make our product sustainable, to shape the wood into our final product will create some waste that cannot be used to process carbon and reject the oxygen that we need later on.

2.1.5 Design for X

Based on the needs of our client and our research for this project we have identified 5 vital elements.

The 5 most important factors in our design are:

- Design for safety: This factor is very important; we must ensure that our design is safe to use to prevent dangerous accidents and injuries.
- Design for accessibility: This factor ensure that the design is accessible by a wide range of users. Our design should have adjustable features.
- Design for independence: The design should have all the features to facilitate user independence in dressing by himself.
- Design for cost: It is important to have an affordable design.
- Design for durability: Our dressing tree should be built to last indefinitely.

3 Problem Definition, Concept Development, and Project Plan

3.1.1 Needs

- Client is a young girl with a condition called Arthrogryposis.
- Arthrogryposis causes muscle weakness and joint stiffness making daily limb operation difficult and limits range of motion.
- Has an occupational therapist, Heather Schulman – hscholman@cheo.on.ca

Table 3. Needs

Need no.		**Function**	**Priority (scale 1-5)**
1		Safely bolted to a wall	1
2		Operates by independent use	1
3		Easy repairability and maintenance	1
4		Adjustable Vertically	1
5		Accommodates all types of clothing	1
6		Withstand normal use	2
7		Last indefinitely	2
8		Compactable size within a room	4
9		Variance for different sizes/lengths of clothing articles	2
10		Portability	5
11		Reliable power system	1

12		Affordable	4
13		Reliable rubber grip	2
14		Aesthetically pleasing	4
15		Easy assembly and disassembly	3
16		Switch/button operated	2
17		Efficiently completes task	5
18		Number of hooks	4
19		Material	5

3.1.2 Problem Statement

Design a safe device that will allow a 7-year-old client to get dressed independently that must adjust with the client's height as she ages and be able to accommodate any type of clothing. Portability would be a bonus.

3.1.3 Metrics

Table 4. Metrics

Need no.	Metric no.	Metric	Priority (1-5)	Units
5	1	Essential clothing articles	1	Types of clothing
12	2	Device cost	4	$
10	3	Device weight	5	Lbs
8,10	4	Device height	2	Meters

4,2	5	Range of motion	1	x, z
4	6	Adjustability range	1	Meters
18	7	Number hooks	4	Hooks
17,18	8	Efficiency	5	Seconds
9	9	Clothing size range	2	Cm
7,3,6	10	Lifetime	2	Years
1,13	11	Stability	1	Yes/no

3.1.4 Benchmarking/Competitor analysis

3.1.5 Dressing Tree 1

Figure 4. Adjustable Dressing Tree Made of PVC

Product Description: This dressing tree is thoughtfully designed for those who may be missing both arms and using prosthetic arms. Constructed with a flexible PVC frame, it accommodates the needs of our client who is a growing child, ensuring that the device remains relevant well into their later years without incurring exorbitant expenses for replacements as they outgrow it. The inclusion of a wooden base adds stability to the structure. Additionally, its user-friendly design allows for effortless disassembly and compact storage, minimizing space requirements and simplifying assembly.

Link: https://www.youtube.com/watch?v=VUeweEsiyhI

3.1.6 Dressing Tree 2

Figure 5. Dressing Tree with Hooks and Metal Frame

Product Description: This specific dressing tree is made of a metal frame and hooks used as “arms” to help the child take of their shirt. Small and compact. Doesn’t seem like this dressing tree can “grow up” with the child, may need to get a new one later.

Link: https://www.facebook.com/watch/?v=266574868900764

3.1.7 Dressing Tree 3

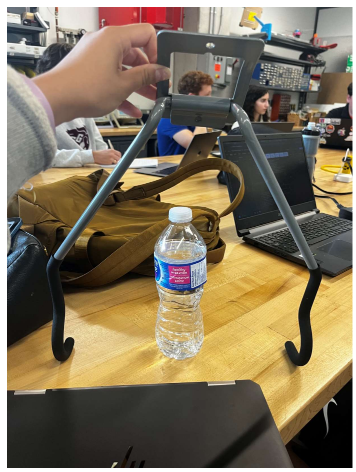


Figure 6. Dressing Tree Hook Attachment

Product Description: This dressing tree hook attachment was brought in by the client. Has hooks that the child can use to take off/put on clothes. Can be mounted onto the wall.

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

Table 5. Benchmarking 1

Need Number	Metric	Unit	Value
1	Essential clothing articles	Types of clothing: (Shirts, pants, underwear, socks)	-
2	Device cost	Dollars	< $100
3	Device weight	Lbs	< 40Lbs
4	Device height	Meters	< 185m
5	Range of motion	x, z (cm)	< (24, 175)cm
6	Adjustability range	Meters	< (24, 175)cm
7	Number hooks	Hooks	< 10
8	Efficiency	Minutes to adjust	< 5 minutes
9	Clothing size range	Cm	< (20cm wide x 170cm tall)
10	Lifetime	Years	10
11	Stability	Force (lbs)	200Lbs

3.1.9 Concept development

Concept 1. A wall-mounted, wooden frame consisting of adjustable channels, grooves, and a stepper motor pulley system.

This concept is based on a stud mounted wooden frame made to accommodate a modular dressing tree system. The system focuses on wooden construction, using milled out channels in the frame to fit dressing hooks, and a central adjustable two-pronged main hook. The channels allow for both manual horizontal and automated vertical adjustability. Vertical adjustability will be controlled by a stepper motor and remote control. This design focuses on the vast adjustability and modularity of different dressing hooks, and well as the structural stability of being wall mounted.

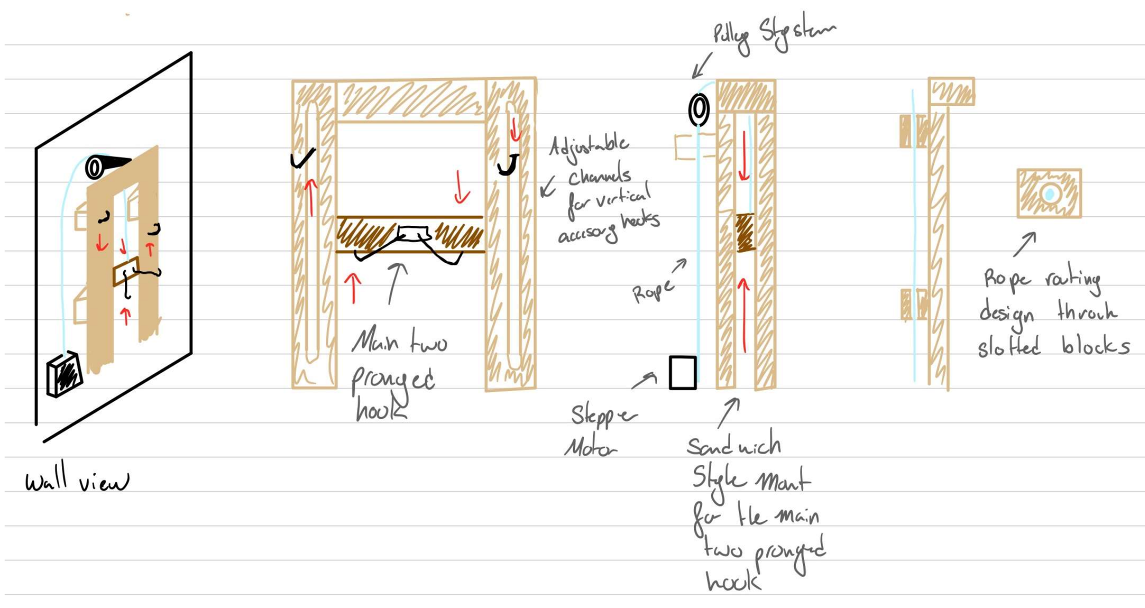


Figure 7. Wooden Frame Design

Table 6. Pros and Cons of Concept 1

Pros	Cons
- Easy modular adjustability - Wide variety of attachment options - Light sturdy construction - Affordable materials	- Many moving pieces subject to wear and tear - Structurally stable but minimal added safety precautions - Complicated to repair or replace simple parts

Concept 2: Wearing ladder

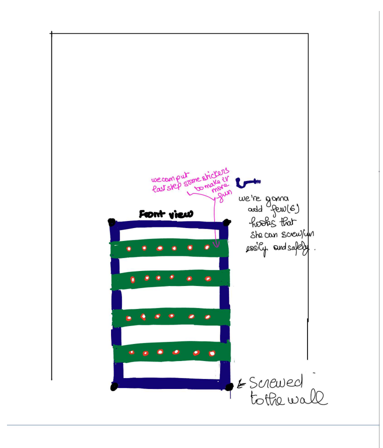


Figure 8. Sketch of the wearing ladder

This concept is in the shape of a ladder fixed to the wall with multiple steps. Each step has several holes to screw the hooks. It will have a few hooks that the user can screw an unscrew as he wants. That way he can adjust the hooks depending on his height and the type of clothing. The hooks can also be put facing different directions, for example to wear socks the hook must face down.

Table 7. Pros and Cons of Concept 2

Pros	Cons
• Adjustable (distance between hooks and the height) • Secure attachment of the hooks at wide 360 degree angle (hooks can face up/down)	• Many parts • Not portable

Concept 3: Adjustable, wall-mounted dressing system

Figure 9. Sketch of the adjustable wall mounted dressing system

This concept is essentially a pole on which a collar is lifted and down by a cable on a pulley that is turned by a motor. The collar is attached to a rail that hooks can be slotted into and adjusted on. This would allow for both the height and width of the hooks to be adjusted.

Table 8. Pros and Cons of Concept 3

Pros	**Cons**
-Very adjustable and would grow with the client -Works with a variety of clothing -simple to use	-Possibly unstable -difficult to manufacture

Concept 4: Pre – Set Hook System

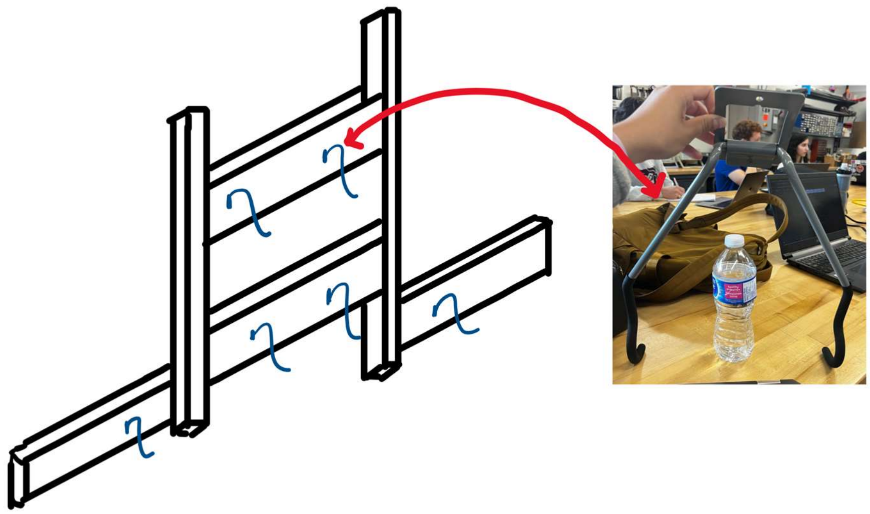


Figure 10. Pre – Set Hook System

This system would consist of removable hooks with pre – set positions. There would be different holes for different positions and heights. The hooks would be made from the client's current dressing device.

Table 9. Pros and Cons of Concept 4

Pros	**Cons**
- Reliable and Sturdy -Works with a variety of clothing - Simple to use - Easy set up and manufacturing	- Limited adjustability (Not custom) - Would need to be rebuilt if vertical adjustability is not sufficient - Not portable

Concept 5: Sketch of the hydraulic standing dressing tree

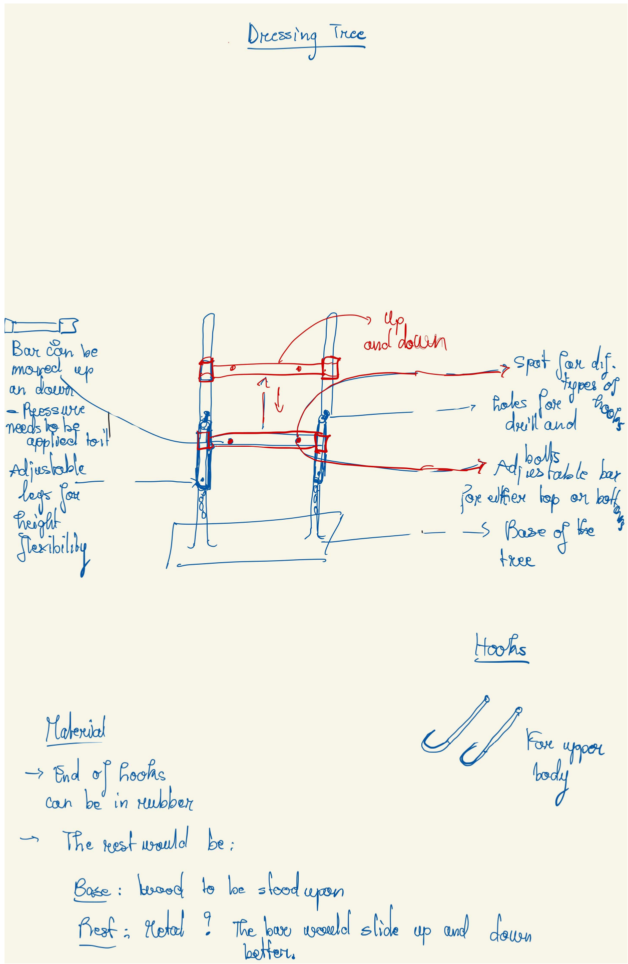


Figure 11. Hydraulic Standing Dressing Tree

This concept is a two-strand dressing tree that would rest on a wooden base against the floor and would be drilled up on the wall. The strands would use the same system as hydraulic desks to make the tree adjustable in height and meet the reality of our client being a growing child and needing a tree that grows with her as well. There would be a horizontal bar in the middle that would be able to slide up and down and allow flexibility depending on the type of clothes that the client puts on. The bar would have two holes made for detachable hooks, allowing flexibility about the type of hooks that would be used, as different hooks can be required depending on the clothing item.

Table 10. Pros and Cons of Concept 5

Pros	**Cons**
-Adjustable and able to meet the changing height of our client -Adaptable to varied types of clothing with changeable hooks and a bar that can be moved up and down. -Solid base that guarantees the stability of the tree as it will be used by a for a child, making it safer. -Reduced chance of the tree falling as it will be drilled into the wall.	-Cost of a hydraulic system (exceeds the budget) -Not a portable a option

Concept 6: Wooden Dressing Tree Frame and Base with adjustable PVC Pipes with Hooks

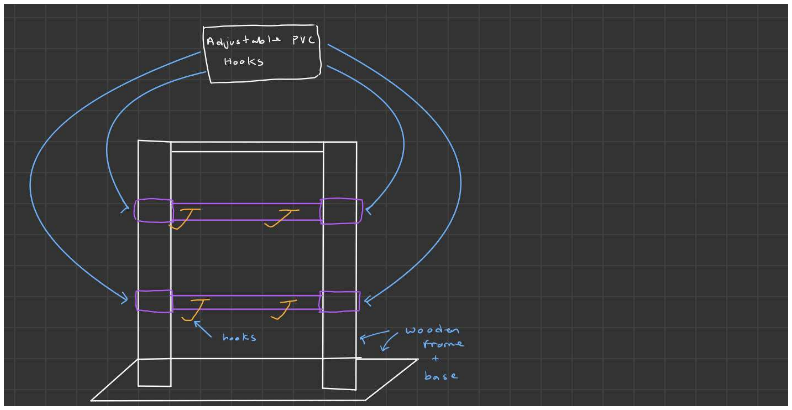


Figure 12. Wooden Dressing Tree

Adjustable PVC with hooks used to help put on/take off clothes for both tops and bottoms with a harness to help the client be balanced. Wooden frame with a base. Easily adjustable so the dressing tree can grow up with the client. Comes with various hooks for different sorts of clothing.

Table 11. Pros and Cons of Concept 6

Pros	Cons
- Adjustable so the client can use it as they grow up - Sturdy frame so it doesn't break with a base so it doesn't fall or tip over - Safe - Simple to use	- Not easily dismantlable - Not portable - Complicated to repair (if wood chips or breaks in anyway)

Final Concept:

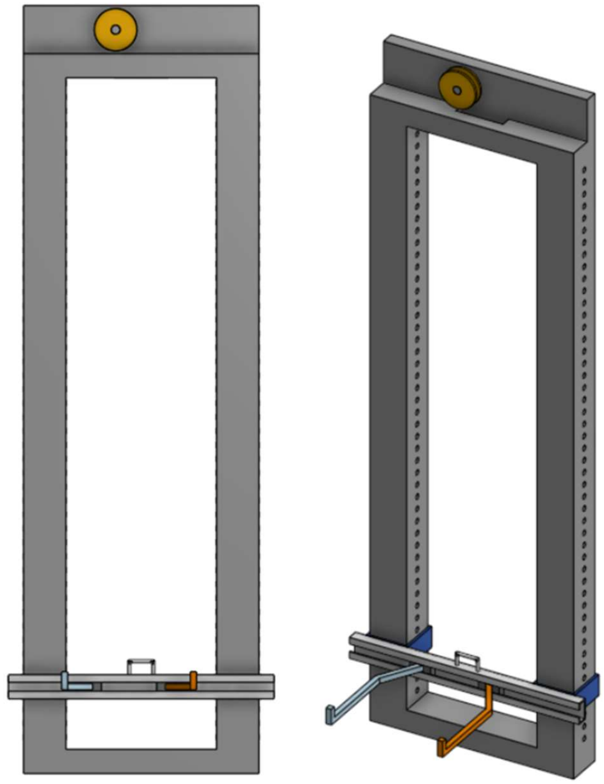


Figure 13. Final Concept

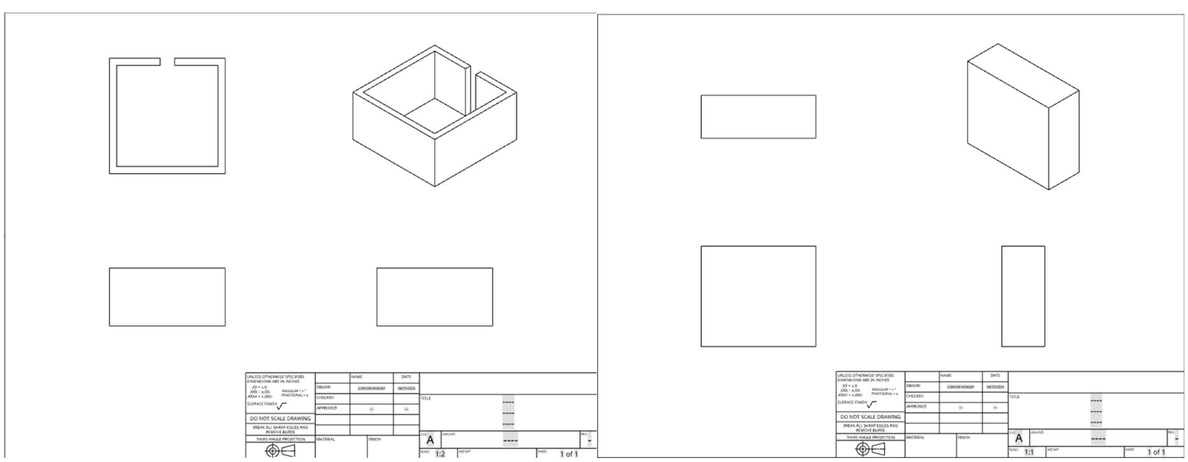


Figure 14. Collar and backing block.

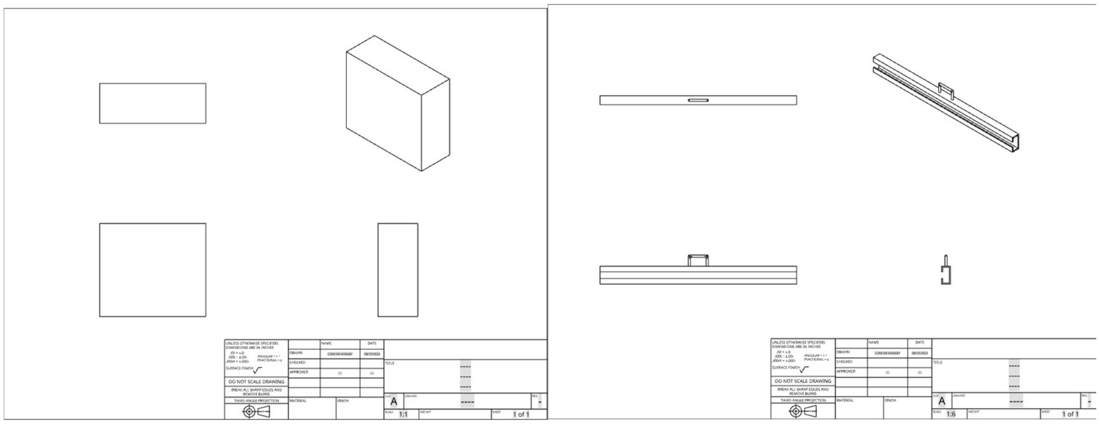


Figure 15. Hook Rail

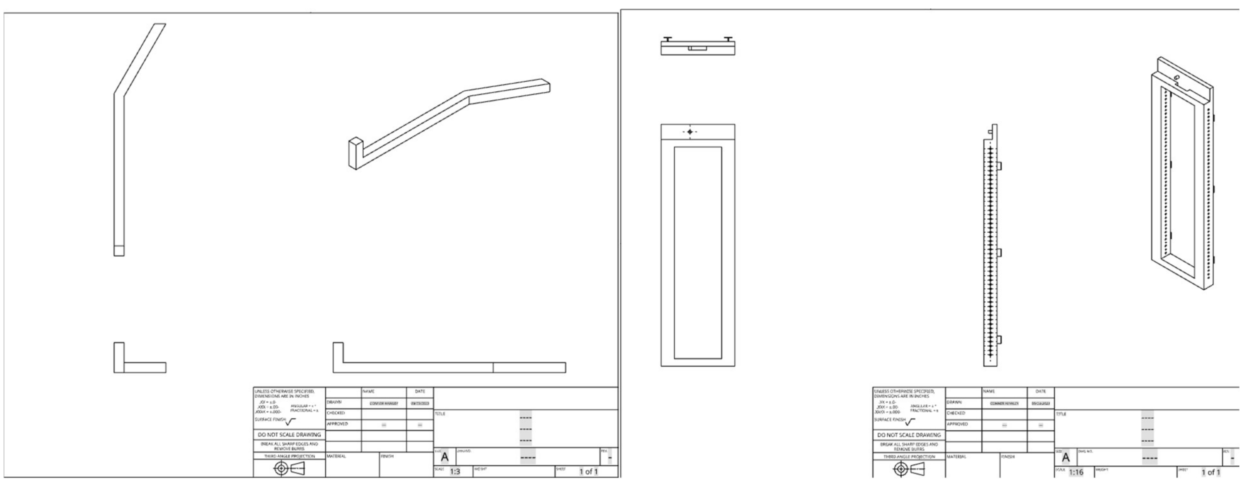


Figure 16. Hook and Frame

Our final Concept is like concept 3 but more stable and easier to build. It consists of two posts on which a rail slides up and down (pulled by a cable mounted to a motor. This allows for a large amount of adjustability in our product as well as the ability for the device to grow with our client. With a 16” center between posts, this device would be able to be bolted to any two standard-spaced wall studs, creating extra stability. The small holes on the sides of the posts will allow for safety pins to be inserted. This will give the rail extra stability as it rests on these pins as well as give a safety backup if the cable were to ever fail. We plan to build the posts and general frame out of wood (most likely 4x4s) and the rail/hooks out of metal. We will put a soft rubber coating on the tips of the hooks for comfort and safety. This should help keep costs down as well as provide good strength, repairability and longevity in our product.

Table 12. Pros and Cons of Final Concept

Pros	**Cons**
-Safe -Grows with our client -Very adjustable -simple to use -Extra safety stops -Able to be installed in any standard house -Standard parts/repairable	-complex -custom hooks -Not portable

3.1.10 Target Specifications

Analyze and evaluate all concepts against the target specifications

Need Number	**Metric**	**Unit**	**Value**	**Concept 1**	**Concept 2**	**Concept 3**	**Concept 4**	**Concept 5**	**Concept 6**

1	Essential clothing articles	Types of clothing: (Shirts, pants, underwear, socks)	-	Yes	Yes	Yes	Yes	Yes	Yes
2	Device cost	Dollars	< $100	Yes	Yes	Yes	Yes	No. Investing in a hydraulic system will exceed the budget on its own.	Yes
3	Device weight	Lbs	< 40Lbs	Yes.	No. The tree is made of multiple parts. Their individual weight added up would exceed the limit.	Yes.	Yes	Yes.	No because of wooden frame, will be > 40 lbs

4	Device height	Meters	< 185m	Yes	Yes	Yes	Yes	Yes	Yes
5	Range of motion	x, z (cm)	< (24, 175)cm						
6	Adjustability range	Meters	<(24,175)cm	No. The height is already fixed. However, the level at which the hooks are can be adjusted within the tree.	No. The tree itself has a set height that cannot be adjusted.	Yes	No, will have preset positions liming adjustability	Yes	Height of frame is fixed but adjustable PVC frames with hooks that can be adjusted in the y direction
7	Number hooks	Hooks	< 10	Yes	Yes	Yes	Yes	Yes	yes
8	Efficiency	Minutes to adjust	< 5 minutes	Yes	Yes	Yes	Yes	Yes.	yes
9	Clothing size range	Cm	< (20cm wide x 170cm tall)		No. The holes for the hooks at the extremities exceed the	Yes	Yes	No. The bar is designed to be larger than 20 cm of width.	yes

					limit of 20 cm.				
10	Lifetime	Years	10	Yes	Yes	Yes	Yes	Yes	yes
11	Stability	Force (lbs)	200Lbs	No	No	No	Yes	Yes	yes

Figure 17. Final Concept Target Specifications

3.1.11 Project plan

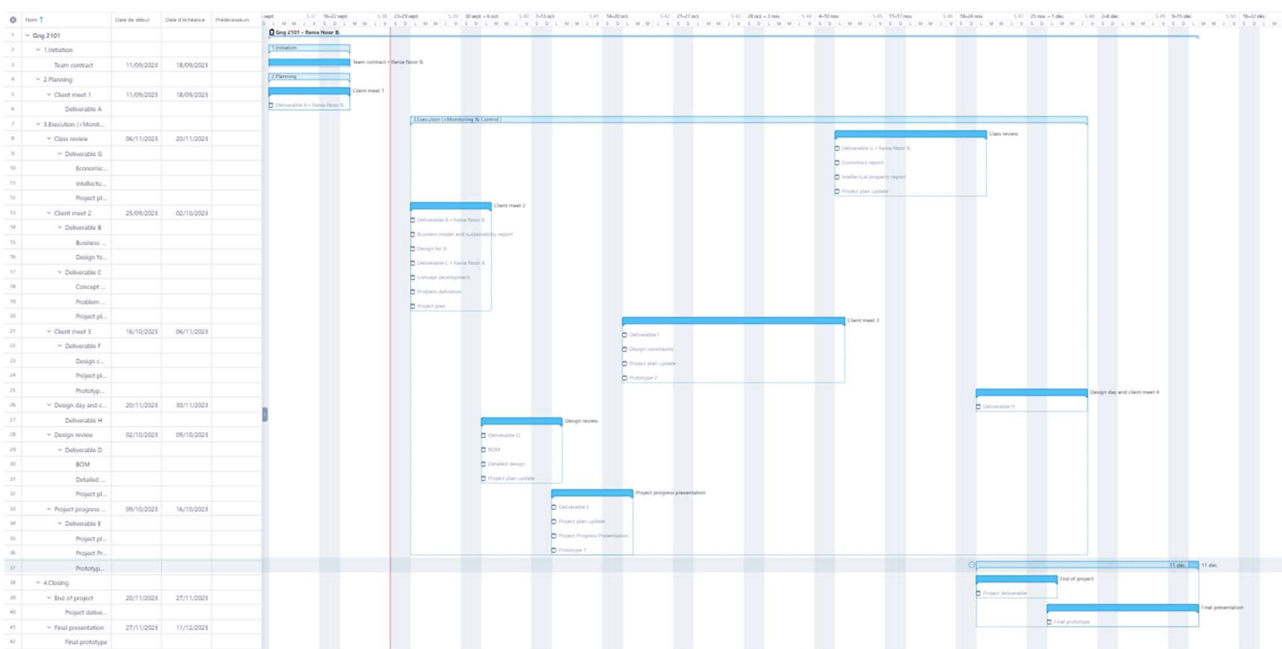


Figure 18. Wrike Project Plan

https://www.wrike.com/frontend/ganttchart/index.html?snapshotId=28vRbvYVmX4zFW1CXGkwxxvYGgNb37KM%7CIE2DSNZVHA2DELSTGIYA

4 Detailed Design and BOM

4.1.1 Client feedback:

Following our recent client meeting, he expressed great satisfaction with our design. He particularly appreciated the adjustability of our design and the concept of incorporating a motor to aid in the operation. Additionally, he suggested that if our design proves to be too wide, we could consider implementing a rail system, allowing the hook to move beneath it. He was content with the height of 6 ft. The only concern he had was about the material selection, as we haven't made a final choice yet.

4.1.2 Time Assessment

Important Deadlines

October 16th-20th : Project Progress Presentation

November 6th-10th : Client meeting 3

November 30th : design day

- The team has weekly meetings on every Wednesday

Actual Available Time

Table 13. Available Time

	Time Left in weeks	Number of labs with available time	Meetings left	Number of available meetings other than Wednesdays
October	2 weeks and ½	1 labs	4 wednesdays	3 days (random day a week)
November	4 weeks	3 labs	1 Wednesday	4 days left
December	0 weeks	0 labs	1 Wednesday	1 days left
Total	6 and ½ weeks	4 labs	6 weekly meetings	8 days

- So far, we haven't dedicated individual tasks for the implementation of our design. Therefore, the assessment of the actual time available to the team provided in the table above applies to each team-member.

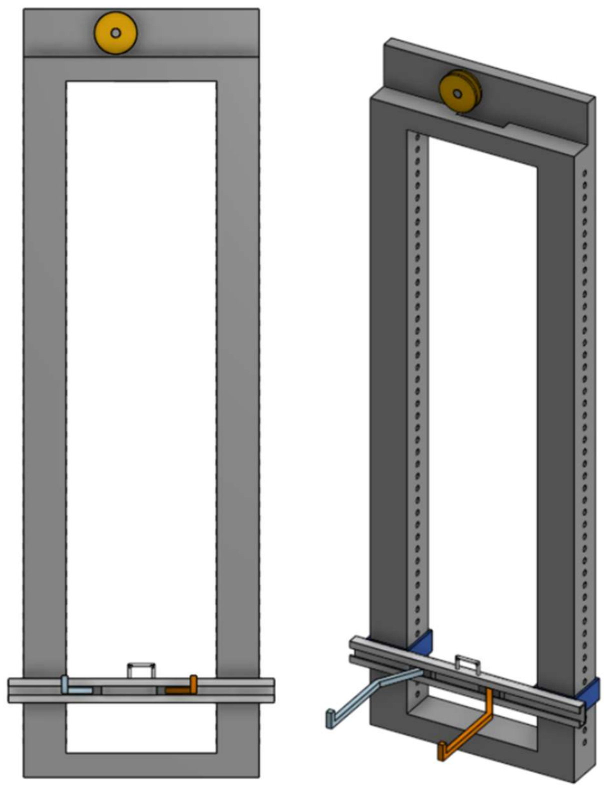
Actual Time Required to Implement Design

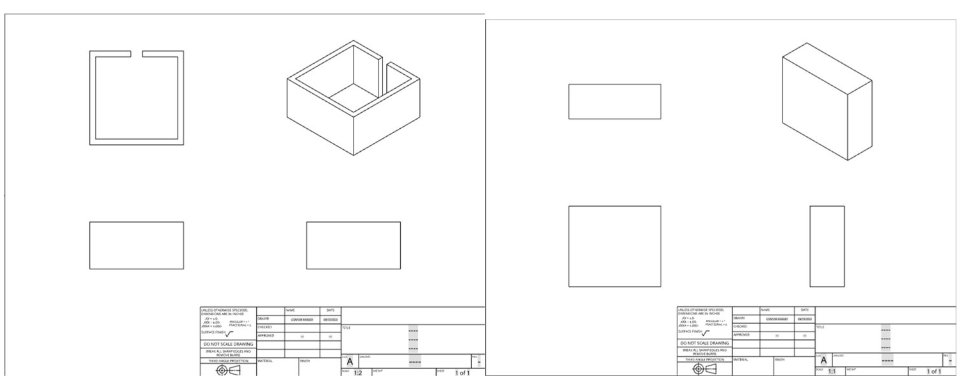
Collar and Backing block: 1 lab, 1 weekly meeting, 1 available meeting other than Wednesday during a week/weekend.

Hook Rail: 1 lab and 2 available meetings other than Wednesday during a week/weekend.

Hook and Frame: 2 labs and 2 available meetings other than Wednesday during a week/weekend

4.1.3 Detailed design





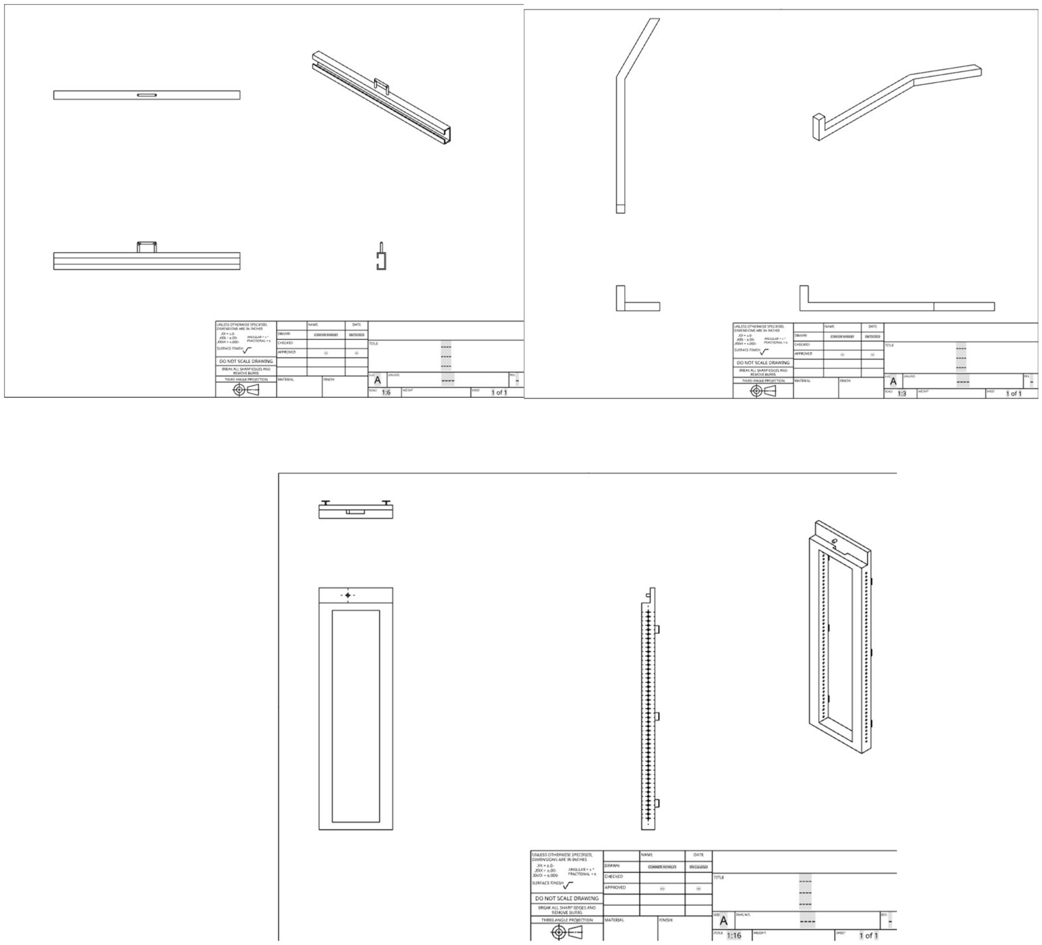


Table 14. Images of Detailed Design

4.1.4 Skills and Resources

Table 15. Skills Needed

Skills	Yes/No
Lathing	Yes
Milling	Yes
C++ Language coding for Arduino	Yes
Solidworks/Onshape	Yes

Cura	Yes
3D Printing	Yes

Table 16. Resources Needed

Resources	Yes/No
Wood	No
Steel	No
Lubrication (oil)	No
Materials for 3D printing	Yes
Screws	No
Motor	No
Rope	No
Brackets	No
Hook	No
Extension Cord	No
Sheet of nylon	No
Gears	No
Pulley	No

Provide a detailed list of skills and resources you have at your disposal that will enable you to create your design. If there are skills or resources missing to complete your design, describe how you will obtain them.

We currently have a online model on OnShape of what our final prototype will look like will fully functioning mates. This was made using our previous knowledge of 3D modelling. We have experience using the 3D printers with the used of Cura in STEM. For the use of Arduino, we know how to code C++ to program our system. From in class laboratories, we have learned how to mill and lathe so this is a skill we can use to create our design.

To obtain the 4x4's of wood and brackets, we will buy them from Home Depot. For the steel or aluminum, we will obtain that from scraps from Brunsfield. To find oil, the hook, rope, screws, we will first look in Brunsfield to limit costs, then we will purchase anything missing from home depot. For a motor, we will find it from a used drill from Facebook marketplace. For the nylon, we will look in Brunsfield, then we will go to Home Hardware to purchase. For the extension chord, we will buy one from Walmart. Any material for 3D printing is provided in STEM. For the pulley, we will create one ourselves, or we will buy one from Home Depot. For the gears, we will buy them from Amazon.

4.1.5 Critical Product Assumptions

There are still several critical product assumptions that still play a role in the ability of us to implement the design for the dressing tree.

These assumptions include:

Weight and Safety Limits: The dressing tree must support the little girl safely. Assumptions regarding weight limits and structural integrity should be based on accurate information to ensure the safety of the girl and the product as well.

Budget and Resources: Assumptions regarding the budget and available resources may impact the choice of materials and design features. Since we have a limited budget on the spending of resources and materials, we need to prepare for any sort of malfunction with a material (I.e., lumber breaks or chips)

Feedback Reliability: Our client has given us amazing feedback about our designs, but we need to assume that the feedback accurately represents the little girl's needs and experiences, ensuring effective communication and understanding the clients feedback is critical.

Maintenance and Repairs: There's an assumption that maintenance and repairs can be easily managed. Challenges in sourcing spare parts could disrupt the product's functionality. Assumptions about the available tools and skills of the caregivers who will be maintaining and helping the girl use the product should be considered as well.

User Education and Training: Assuming that the little girl and her caregives can easily learn how to use the dressing tree based on their feedback. Design features should align with their abilities and understanding.

Backup Plans and Contingencies: Preparing for unforeseen circumstances or changes in the client's preferences or circumstances that may necessitate adjustments to the product design.

User Well-being and Comfort: Ensuring that the dressing tree continues to prioritize the well-being and comfort of the user remains as a critical assumption. User feedback should guide any design changes that affect these aspects.

4.1.6 BOM

Part #	Part Name	Description	Cost ($)	Product Link
1	Garage storage hook	Storage hook for use as the dressing tree main hook	7.98	Hook
2	Drill	For use as motor	5.00	Drill
3	Extension cord	Power to motor	8.49	Extension Cord
4	Rope	For pulley system	0.76/ft, 9.88	Rope
5	Lumber 4x4x12	For vertical support	25.18	Lumber
6	Lumber 2x4x8	Horizontal support	3.98	Lumber
7	Pulley	Pulley	7.49	Pulley
8	Non Latching Push Buttons	For up Down Motions	5.00	Buttons
9	Square piping (steel) 2ft	For center brace	Brunsfield Pricing	
12	Gear set	For torque multiplying gearbox	12.35	Gear Set
13				

14				
Total				
Total Used			85.35	
Total Remaining			14.65	

Table 17. Bill of Materials

4.1.7 Project plan update

https://www.wrike.com/frontend/ganttchart/index.html?snapshotId=DJoqy81wHiWgtPFuGnnO6EjHf9VPwD4a%7CIE2DSNZVHA2DELSTGIYA

5 Prototype 1, Project Progress Presentation, Peer Feedback and Team Dynamics

5.1.1 Prototype 1

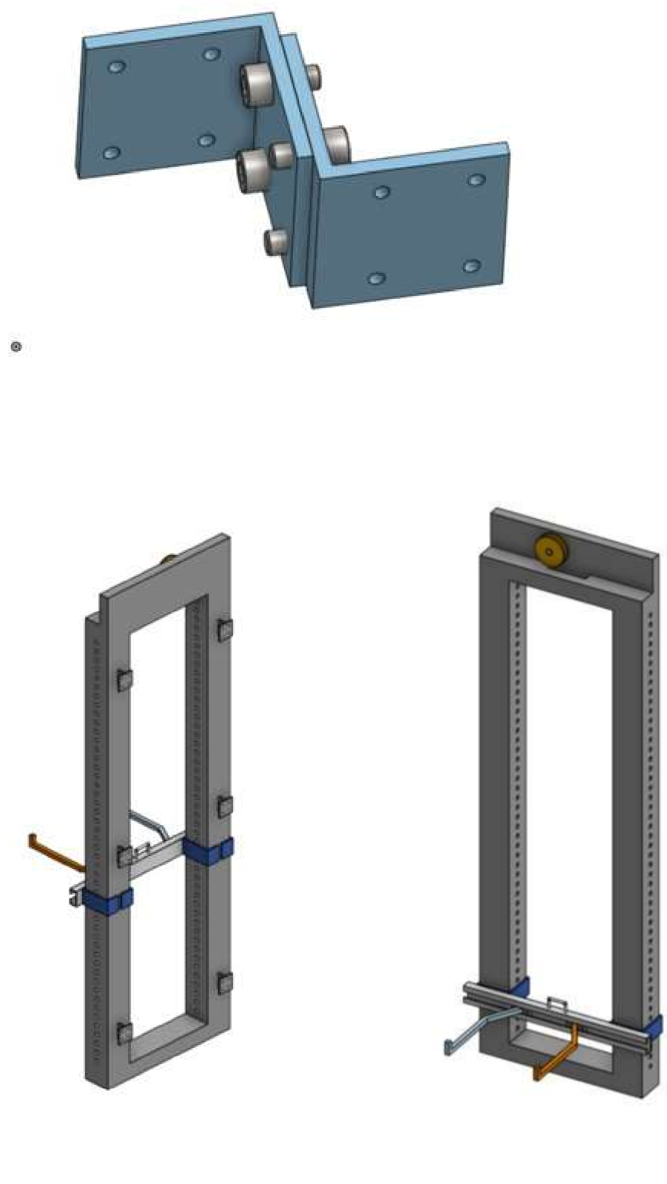


Figure 19. CAD Models

5.1.2 Project Progress Presentation

Presentation.pptx

5.1.3 Project plan update

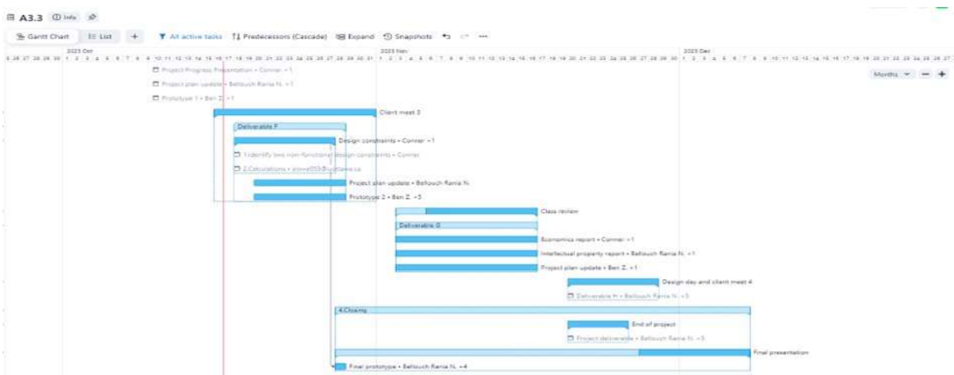


Figure 20. Wrike Snapshot

https://www.wrike.com/frontend/ganttchart/index.html?snapshotId=sebnrmtldDaLbBBRk8pcVAH5Ml5UddlU%7CIE2DSNZVHA2DELSTGIYA

6 Design Constraints and Prototype 2

6.1.1 Design constraints

6.1.2 Non – Functional Design constraint 1: Performance and usability

The most important design constraint in this project was the safety of our product, regarding the fact that our client is as young as 7 years old and suffers from Arthrogryposis. Furthermore, the product is to be used by the client on her own for more independence on a daily basis. We made sure to incorporate this constraint in our design by reducing the amount of sharp edges and protrusions as much as we could. An example would be the hooks that were coated at the tip since this part would come more often in contact with our client when using the dressing tree. Moreover, we designed the tree to be bolted to the wall as a measure of maximal security. This was, the possibility of the tree being unstable, wobbly or falling over our client and potentially causing a deadly incident was eliminated, making our product even safer. Last but not least, we ran into an issue where our adjustable hooks were getting stuck and needed a lot of physical force to be unstuck. This had to be urgently resolved as our client has limited motor skills and does not possess enough physical strength to face a situation like the one we faced. We therefore spent a considerable amount of our time sanding our wooden support frame to increase how smooth the up and down motion of the adjustable hook was. This made sure to eliminate the possibility of the hooks being stuck at some point, and requiring a lot of force to unstuck them.

6.1.3 Non – Functional Design constraint 2: Aesthetics

Once our prototype is fully wired and can perform as desired, the final step is the aesthetics of our prototype. Since we are designing this dressing tree for a 7-year-old year, we plan to color, and add LED lights. Initially, we planned to paint the prototype a shade of pink, but since this machine will likely be used as she gets older, we decided to use a pink wood stain for a more mature look as she gets older. A second non-functional design constraint in our project was the aesthetic consideration of multiple times, our client is very young, 7 years old more specifically and a girl.

Her father let us know that the dressing tree would be mounted to the wall of her room to allow for easy access, and give her the opportunity of getting dressed on her own every day. As the tree was being added permanently to her room, and keeping in mind that children are sensitive to colors and the general appearance of their environment, we as a team wanted to make our product as likable to the young girl as possible. We therefore asked for her favorite color, which is pink, and make sure to add a coat of the paint over the wood used for our final design to enhance her overall experience using the tree. However, for lack of time and budget, we were limited to one coat of pink spray paint over the entire wooden structure and a part of the hooks as well. We would rather use a more durable alternative and be able to apply multiple coats of the color to make it more durable.

Figure 21. Comparison between Pink Paint and a Wood Stain

6.1.4 Client Feedback

Client is happy with our progress, he liked being able to interact with the physical prototype. Instead of our suggested idea of alligator clips for a different hook, he wants 1 large hook and 1 small hook. Instead of planning for the hooks to support a weight of 400lbs, client is okay with 200lbs allowing us to focus more on the safety of the overall supports. He likes the idea of coloring the tree pink, as well as the idea of adding LED lights to the back.

6.1.5 Critical Product Assumption

Most Critical Product Assumption not tested yet.

The most critical product assumption that we have still not tested yet is the **Backup Plans and Contingencies.** Since we have not yet tested the product electrically and only mechanically, we cannot test the prototype to its full ability, only through each subsystem. In order to preparing for unforeseen circumstances that may necessitate adjustments to the product design, we must finish the wiring and carry out more prototype testing.

Critical Product Assumptions tested through Development.

As we were developing our design, we were able to overcome budgeting and resources because we have all the materials needed to build our final prototype (in addition to considering spare parts). Our final cost spend was $140. The weight and safety limit was tested as our hooks can withstand well over the updated amount needed to support (200lbs). Since the structure of the dressing tree will be mounted to the wall, we can ensure zero movement and complete rigidity. The mechanical aspect of maintenance and repairs by ensuring spare parts and screws are compatible with the current model. The feedback reliability was tested throughout the development of our prototype, however this critical assumption is ongoing as communication based on new progress is regularly updated to our client.

6.1.6 Updated Prototype 2

6.1.7 Subsystem 1: The Horizontal Dressing Bar

The Horizontal Dressing Bar, made from extruded steel with welded hooks, offers a sturdy and adjustable design for easy. Its low friction acrylic collars are specifically designed to minimize friction on subsystem 2, optimizing performance and durability.

Figure 22. Horizontal Dressing Bar

6.1.8 Subsystem 2: The Vertical Wall Mount

The vertical wall-mounted structure is constructed using robust wood, incorporating 4x4 pillars and 2x4 cross members to ensure stability and strength. It is designed with safety in mind, featuring safety pins for secure assembly and use. Additionally, the design includes a channel that allows for easy wall mounting and maximum vertical adjustability, making it a versatile addition to any space requiring such a wooden installation.

Figure 23. The Vertical Wall Mount

6.1.9 Subsystem 3: Motor Component

The apparatus includes a ground-mounted, 115-volt high-torque motor that's thermally protected for longevity. It's designed to plug into a wall outlet and utilizes a brass worm gear paired with a 68T straight gear to efficiently deliver power to the pulley system.

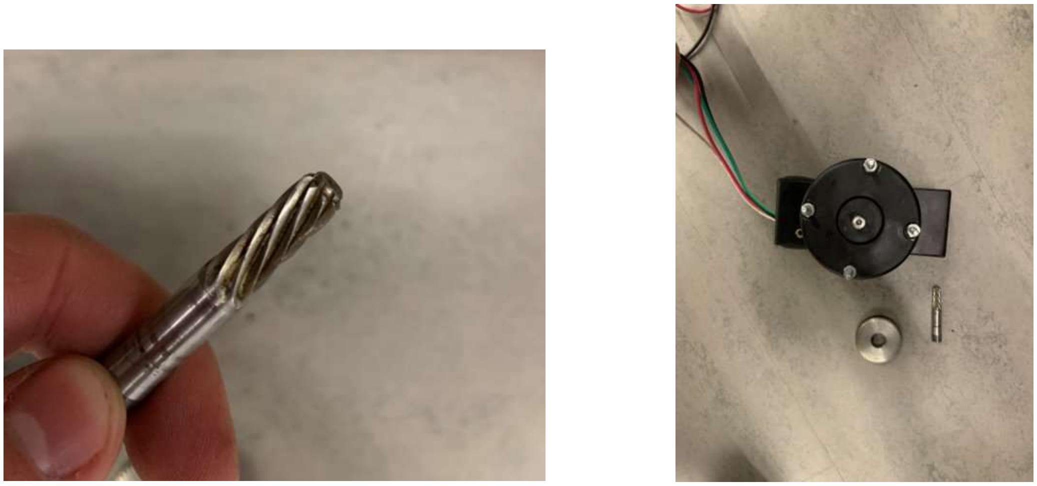


Figure 24. The Motor and Gears

6.1.10 Full Prototype

Figure 25. Final Prototype

So far, we have combined subsystems 1 and 2, as well as the brackets that will be mounted to the wall, and the pulley.

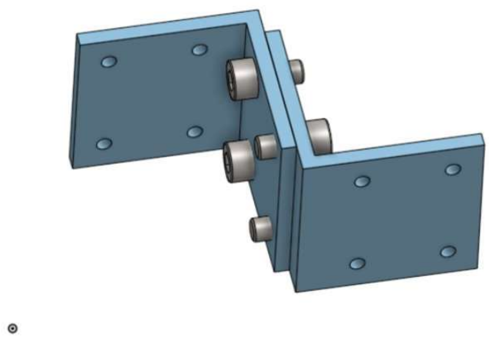
6.1.11 Prototype Testing

Need Number	Metric	Unit	Value	Results
1	Essential clothing articles	Types of clothing: (Shirts, pants, underwear, socks)	-	Not yet tested
2	Device cost	Dollars	< $100	<$150
3	Device weight	Lbs	< 40Lbs	25Lbs
4	Device height	Meters	< 185m	180cm
5	Range of motion	x, z (cm)	< (24, 175)cm	24, 175
6	Adjustability range	Meters	< (24, 175)cm	24, 175
7	Number hooks	Hooks	< 10	2
8	Efficiency	Minutes to adjust	< 5 minutes	Not yet tested
9	Clothing size range	Cm	< (20cm wide x 170cm tall)	Not yet tested

10	Lifetime	Years	10	Predicted 10
11	Stability	Force (lbs)	200Lbs	200 lbs

Table 18. Prototype Testing

6.1.12 Future Prototype



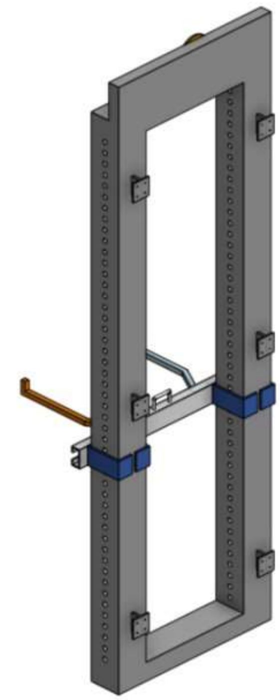


Figure 26. CAD Models

6.1.13 Future Plans

Date	Activity
Nov 10th	Revisit design of Subsystem 1
Nov 15th	Construct wood frame for Subsystem
Nov 16th	Conduct stress testing on Subsystems 1 and 2
Nov 18th	Mount wall brackets and conduct more testing
Nov 20th	

	Pulley, motor and gearbox construction, wiring and mounting.
Nov 21th +	Aesthetics and presentation

Figure 27. Future Plans

Future Client Meet

We will not officially have a next client meeting. Instead, we have design day to present our final prototype and gain final insights from the client. We hope to answer any remaining questions the client has so they could maintain and function the prototype by themselves.

6.1.14 Project plan update

https://www.wrike.com/frontend/ganttchart/index.html?snapshotId=kPTKPkyMgvFLep26Uo5vQNIJIJfmPKl9%7CIE2DSNZVHA2DELSTGIYA

7 Economics Report

7.1.1 Cost of Manufacturing and Sales

Type	Variable/Fixed	Direct/Indirect	Material/Labor/Overhead	Description
Material	Variable	Direct	Material	Cost of: - Wood - Aluminum - Pulley

				- Buttons - Screws
Labour	Variable	Direct	Labor	Cost of manpower for manufacturing
Machine use	Fixed	Indirect	Overhead	Cost of machinery use
Utility Bills	Fixed	Indirect	Overhead	Cost of: - Electricity - Water
Packaging	Variable	Direct	Material	Cost of packaging materials
Shipping	Variable	Direct	Overhead	Cost of the final product
Marketing	Variable	Indirect	Overhead	Advertising and promotional costs
R&D	Variable	Indirect	Labor	Research and development costs
Prototyping	Variable	Direct	Material/Labor	Cost for each prototype

Maintenance	Fixed	Indirect	Overhead	Regular maintenance of equipment

Table 19. Cost of Manufacturing and Sales

7.1.2 3-year Income Statement

Assumptions:

- Sell 100 units during our first year, with an increase by 20% each year

- $200 per dressing tree

- Cost per unit = $150

Year	Units Sold	Sales Revenue	Cost of Goods Sold	Gross Profit	Operating Expenses	Operating Income
1	100	$20,000	$15,000	$5,000	$4,000	$1,000
2	120	$24,000	$18,000	$6,000	$4,800	$1,200
3	144	$28,800	$21,600	$7,760	$5,760	$1,440

Table 20. Economics of the Next 3 Years

7.1.3 NPV analysis:

Based on these assumptions:

-Sell 100 units during the first year, with an increase by 20% each year.

- $200 per dressing tree.

- Cost per unit = $150.

- Discount rate : 10%

Year 1:

Cost of Goods Sold (COGS): $15,000

Present Value (PV) of COGS: $13,636.36

Operating Expenses: $4,000

PV of Operating Expenses: $3,636.36

Total PV of Outflows: $17,272.73

Year 2:

Cost of Goods Sold (COGS): $18,000

Present Value (PV) of COGS: $14,876.03

Operating Expenses: $4,800

PV of Operating Expenses: $3,966.94

Total PV of Outflows: $18,842.98

Year 3:

Cost of Goods Sold (COGS): $21,600

Present Value (PV) of COGS: $16,228.40

Operating Expenses: $5,760

PV of Operating Expenses: $4,327.57

Total PV of Outflows: $20,555.97

The break-even point is where the NPV is zero. The initial assumption of selling 100 units in the first year with a 20% increase each subsequent year already yields a positive NPV. This implies that under these conditions and with the given discount rate, the business is expected to be profitable from the start, without the need to increase the number of units sold to break even.

8.4 - Assumptions in the report

1. Initial Sales and Growth Rate

- Assumption: The preliminary market research suggests an initial sales projection of 100 units in the first year with a subsequent 20% annual growth rate.
- Justification: This assumption is grounded in early market assessments, indicating a moderate demand and anticipating a gradual increase in acceptance and market share over time.

2. Unit Price

- Assumption: The pricing strategy sets the unit price at $200 per dressing tree.

- Justification: The pricing decision is informed by an evaluation of the product's perceived value, competitive pricing dynamics, and the consideration of production costs. The aim is to establish a competitive yet profitable pricing strategy (Smith, 2022).

3. Cost per Unit:

- Assumption: The estimated cost per unit is $150.
- Justification: This cost is determined through a comprehensive analysis of production expenses, encompassing materials, labor, and overhead. The goal is to ensure a realistic cost structure while maintaining.

profitability (Jones, 2021).

4. Discount Rate:

- Assumption: A 10% discount rate is applied for present value calculations.
- Justification: The choice of a 10% discount rate is aligned with prevalent market interest rates and factors in the perceived risk associated with the business venture (Brealey et al., 2020).

5. Cost of Goods Sold and Operating Expenses:

- Assumption: COGS and operating expenses are estimated based on industry standards and cost structures.
- Justification: These estimates are derived from a combination of internal cost analyses and industry benchmarks to reflect typical cost structures in the relevant market (Hitt et al., 2019).

6. Break-even Point and NPV:

- Assumption: The break-even point is determined at the NPV zero.
- Justification: This assumption aligns with standard financial metrics, indicating that the business is expected to be profitable from the outset, as evidenced by a positive NPV under the specified conditions (Ross et al., 2019).

It is important to acknowledge that these assumptions are formulated based on a hypothetical scenario and should be subject to ongoing reassessment as more concrete market data becomes available throughout the business development process.

8 Intellectual Property Report

By exploring the Canadian Intellectual Office's website and the FPO, two properties that relate to our project are Trademarks and copyrights.

a. http://cipo.gc.ca

b. http://www.freepatentsonline.com/

c. http://patft.uspto.gov/

a. https://patents.google.com/ or other

2. Explain the importance of these intellectual properties and the legal constraints they place on developing your product or business

Trademarks: A requirement for our project this year was to come up with a name for our team, so that our work could be identified by our classmates, professors, teacher assistants and the jury on the final design day. This name is an element of our identity as a team, and requires protection, especially when planning to start a business and coming up with a business plan. Trademarks are known to create a link between a product and the quality of the brand that is responsible for putting the product out, therefore avoiding any confusion in the minds of customers when the market already proposes products like the one we have. Finally, Trademarks offer legal protection against any unauthorized imitation as an example, allowing us to take legal action and be compensated in case such a scenario happens.

Copyrights: As our client is a seven-year-old seeking more independence in her daily routine of getting dressed up, we as a team have also looked into making the dressing tree more adaptable and more pleasant to incorporate in not only her routine, but environment as well. An example is painting the dressing tree her favorite color, pink. From our research, we understand that copyrights are used to protect the original and artistic aspects of a product. Ours would be the color and the adaptability of our tree to her developing self, as a seven-year-old is expected to grow in height and width with time.

8.1 Project plan update

wrike snapshot

9 Design Day Pitch and Final Prototype Evaluation

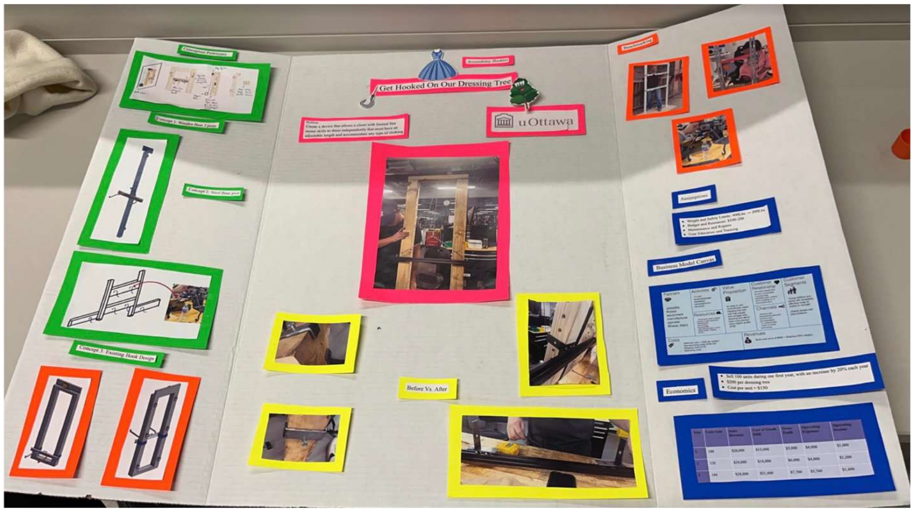


Table 21. Design Day Display

10 Video and User Manual

10.1 Video Pitch

https://www.youtube.com/watch?v=zKEYxahVe9s&ab_channel=SamiLowe

10.2 User manual

User and Product Manual Group A3.3

11 Conclusions

In concluding this report, we reflect on the valuable lessons learned throughout our project's journey in developing assistive technology for children with limited fine mobility. A paramount lesson was the need to prioritize safety in every aspect of our design, ensuring that our device not only aids independence but also protects the well-being of its users. Through iterative prototyping, we embraced the importance of gradual improvement, learning that each iteration brought us closer to a more effective and user-friendly solution. Budgeting emerged as a crucial skill, highlighting the need to balance cost with quality to deliver a viable product. Time management was another critical lesson, teaching us the importance of meeting deadlines while maintaining the integrity of our work. The project also reinforced the value of teamwork and communication skills, as these were instrumental in overcoming challenges and achieving our collective goal. These lessons, ranging from technical aspects to interpersonal skills, have not only been instrumental in the success of our current project but will also guide us in future endeavors, ensuring continual growth and improvement in our field.