ENGINEERING

McMaster University

Project Four – Power in Community:

ENGINEER 1P13 – Integrated Cornerstone Design Projects

Tutorial 05

Tues-33

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Submitted: April 13, 2021

Table of Contents

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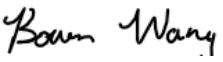
Bowen Wang 400325152

X 

Executive Summary

In project four, the engineering design team will be focusing on a real word issue within our local community.[1] The team is required to tackle on one or multiple challenges that our client- Alaana faces in her everyday life due to the impact of Spondylarthritis, Fibromyalgia and Lymphoedema, work through the engineering design process and derive a solution that will improve her overall quality of life.

The final protype is a universal handle that assists Alaana with gripping small objects and perform tasks with precision, the shape of the handle is ergonomically designed in terms of comforts and provides a firm hand support with the curved handle and easy finger slots.[Fig 22] The structure of the device contains two assembled parts, the outer layer is an ergonomic handle that matches the size of our clients' hands, made from silicone-a low thermal conductive material that minimize the heat sensitivity due to lymphoedema. The inner part is a changeable rubber slots with high flexibility, we applied the cross design at the center that allows it to firmly retain a variety of inserted utensil, and the size of the rubber slots are customizable for tools of different sizes. The benefits of this device are to physically improve Alaana's grip strength, significantly increase the number of everyday tasks that our client can perform and provide her with a comfort and a painless working experience.

Moving on forward, due to the limit of an online learning environment and time issue, there is still refinement could be made of our device. If more resources are provided, the team will continue on to create a physical prototype with the respective materials, expand the test plans under the consideration of different user conditions and finally having the client actually try to use our design and provide constructive feedback for further improvements.

Introduction

Our client Alaana is faced with more than one autoimmune condition, affecting nearly every area of her daily life. Essential tasks such as cooking, eating, driving, and taking care of her children have been made significantly more difficult by the compounding effects of fibromyalgia, spondylarthritis, and lymphedema. Upon interview, Alaana listed the different therapies and professionals she sought out for treatment, such as physiotherapists, osteopaths, chiropractors, etc. Additionally, she discussed products/tools that she already uses including a cane, tens machine and vibrating heat belt [Fig. 1]. These tools helped to alleviate her pain temporarily, but they did not provide her with a level of comfort that she needed to carry out her daily activities. Specifically, our team noted the discomfort in her hands caused by fibromyalgia, a condition characterized by musculoskeletal pain.

Having initially analyzed Alaana's needs, we refined our problem statement – design a device that will increase overall mobility while maximizing comfort. With this device, the client will be able to perform more of her daily tasks with less difficulty. Accordingly, we came up with objectives and constraints for the device to meet. We prioritized the tool's durability, and ability to reduce fatigue while increasing comfort. The rest of our objectives included supporting her hands, increasing hand (grip) strength, and increasing the number of tasks she could complete. We set constraints based on the factors that were most desirable to her. Our device had to be light (under 10 pounds), easy to use, and utilize a grip type similar to the one she was already familiar with [Fig. 3].

Alaana expressed interest in an assistive tool she could use while painting, that used a wide, flat handle. This sparked multiple group members' interest to conduct research on existing products that meet some of these criteria. A common tool used by artists is a mahl stick, a pole approximately a meter in length with a ball to lean on the artist's surface for support. Pencil or ball grips were also extremely popular for use of a thin instrument like a paintbrush [12]. However, none of the products encompassed all of the elements our client was looking for. Finally, we found a patented product called the EazyHold – an adaptable cuff allowing the user to hold onto a multitude of items with ease. Its use extended to individuals with spinal cord injuries, cerebral palsy, arthritis, or other conditions that impacted their fine motor skills [Fig. 2]. The existence of this product type gave us a concrete starting point, and we started to create a design that met all of our objectives.

Conceptual Design

Before creating our conceptual design, we created functions and objectives that we wanted our design to have. Every initial design and change made encompassed these functions and objectives to ensure our design was ideal for the client. We decided our functions early on in milestone 2 using our morph chart [Figure 4]. These functions were specifically designed to assist the client and help us to develop designs to solve our problem statement [Figure 5]. With each function, we developed a minimum of six means that could be potential design ideas to accomplish that function. They were very diverse to allow for a wide variety of concepts. After the completion of the chart, each team member came up with two initial concepts and sketched them out [Figures 6-10].

The next phase of conceptual design was the prototyping phase. Each team member constructed a prototype that built off their initial concept sketch [Figure 11-15]. The prototypes had two main categories; one to hold a paintbrush and the other to hold the client's arm/hand while painting. Figures 12 and 15 focused on the concept of inserting the paintbrush into the holder, but in two different methods. One was a large grip while the other was just a handle or strap around the client's hand. Figure 14 focused on supporting the client's arm with stackable blocks, while figure 13 focused on supporting the client's hand while moving. We found these two designs to be quite complicated and harder to use.

After everyone had made their prototype, we created a decision matrix. We included some of the functions from our initial morph chart and decided which ones were more important for our success. This was done in figure 16 and the top three criteria were comfort, supporting her hands, and increasing arm strength. Then, we took each prototype and decided how well it did on a scale from 1-5. 5 was perfectly, 1 was not at all. The weighting was applied to that score and all the scores were totaled. This helped us choose our top two designs for our design review [Figure 17]. The two that ranked highest were Arm support on wheels and ergonomic rubber handle with paintbrush grip. In figure 18, we explain in depth why these two were chosen above the other prototypes.

Next, we took our two designs to the design review for feedback from IAI's and science students. They gave us valuable feedback that we recorded in our worksheet [Figure 19]. We realized that the arm holder on wheels would need a lot of changes to be better and had a few major flaws. This was since it cannot go up or down easily, and it could roll and fall off or damage the painting. The ergonomic rubber handle was a lot more feasible to create and build upon to improve it further.

We talked to a couple TAs about the decision between the two and they both said to keep it simple. This was because it would be easier to work with and the client would not have trouble learning how to use it. Especially for someone with arthritis and pain in her joints, making something with fewer parts and less confusing would be a huge benefit to the design.

Now that we had decided which of the two designs to proceed with, we had to make some further refinements based on the science student's feedback. They talked a lot about what material we were using [Figure 19], which we had not thought about a lot. We knew we were using rubber, but we did not think about how the material would interact with the client. The science students pointed out how we needed to use a thermoneutral material so the client's hands would not get too hot while using the device. After these changes, we had a more refined concept [Figure 20]. This design was taken to another design review for more feedback.

By taking our refined concept to the science students a second time, we documented more feedback [Figure 21]. We decided to go with a silicone exterior because it is lightweight, thermoneutral, flexible, and has good grip. After deciding to make a paintbrush holder, we took inspiration from the initial prototypes [Figures 12 and 15]. Both those prototypes had the idea of inserting the paintbrush into the holder instead of a screw design. This screw design would be a lot harder to use for the client due to small parts. We removed the requirement of securing the brush with a screw and created inserts with a cross design, inspired by other products online [4]. The inserts would come in different sizes and be able to hold a wide variety of tools. We also added finger grooves for increased comfort and to be more ergonomic. This was suggested by the science students.

From our initial sketches, our design changed a lot in how it worked, the material, and the shape. The use of a decision matrix helped us decide on two main ideas by taking feedback from TA's, science students, and IAI's, we decided on one design. We made key changes by getting more feedback, resulting in a very effective design. Key decisions were made based on what we thought was the best way to accomplish the functions we made. The design process played a key role in the final product we have today.

Final Proposed Design

The proposed design is a multi-purpose handle. This device was created to be versatile, portable and help the client accomplish more tasks. It has a changeable slot inside, a slot at the top (mainly for painting), so the client just pushes the tool (paint brush, spoon etc.) she wants to use inside. The device also has finger grooves for grip. This grip has an advantage for our objective “easy to use” and “increase comfort”. The client would not have to worry about having pains in her wrist or not been able to do her tasks while using this tool. This device was created to have a wide space for her hand for comfort and breathability. The top secures her hand on the device. The slot was placed at the bottom so she can place any tool easily without bending or twisting her wrist. The device slot was designed to be able to accommodate any tool width size. The cross design in the center holds the tool firmly. The ergonomic shape of the handle will maximize the comfort and reduce fatigue.

After concluding on our finalised design, we thought of using the best material to create this device for the user’s comfort and safety, portability, and durability. We chose to use silicon to make the handle since it tends to be utilized in temperatures between - 50 °C to 230 °C. [2] Also, it is fire resistant and has excellent resistance to the weather. It additionally has a tensile strength of 5MPa. [2] It can withstand warming and freezing without leaching or off-gassing, unsafe synthetic compounds. Moreover, it is additionally impervious to stain and odor, it is hypoallergenic, and because of its smooth surface, the customer will find it very easy to clean. It is also eco-friendly, non-toxic, and very durable so the customer would not need to stress over it get destroyed. The changeable slots will be made using rubber material because of its high tensile strength, tear strength and abrasion resistance. The silicon and rubber materials are not heavy which will make it easier for the client to carry around and increase her arm strength. The device met all the objectives which include supporting her hands, increasing comfort, reducing fatigue, easy to use, increase arm strength, increase tasks she can complete and durability.

Conclusion

Though we were satisfied with our design and prototype given our limitations, the design can be vastly improved given more time. Being able to create a physical product of our prototype with the respective materials would have allowed us to see how it behaves. Furthermore, a physical prototype would have allowed us to test it in different conditions that the client might face. Another component that we wish it had been possible is having the client try out our product. By seeing how the client interacts with the device we could have made further improvements with the critique she will give.

Throughout this project, we utilized a variety of decision-making tools, when creating our design. This really showed how thorough the design process needs to be. The decision-making process was the lengthiest part of the project, however we soon realized it's necessity as it was hard to choose between different idea. This also relates back to our team dynamic, as we had all designed separate tools [Fig.5-9]. This was a cause of conflict as we all had our preferences, however again the decision-matrices and morph charts [Fig.3], aided us to choose our final prototype [Fig.21]. Next time it might be better for us to create a design together, as we all had good ideas that could have been integrated together if we had more Creating a design together would have also allowed us to get opinions on our semi-developed ideas. Having a concrete schedule would have allowed to be more efficient and work further than we currently have.

*List of Source*s

[1] “P4 Project Module,” class notes for ENGINEER 1P13A, Department of Engineering, McMaster University, Winter, 2021.

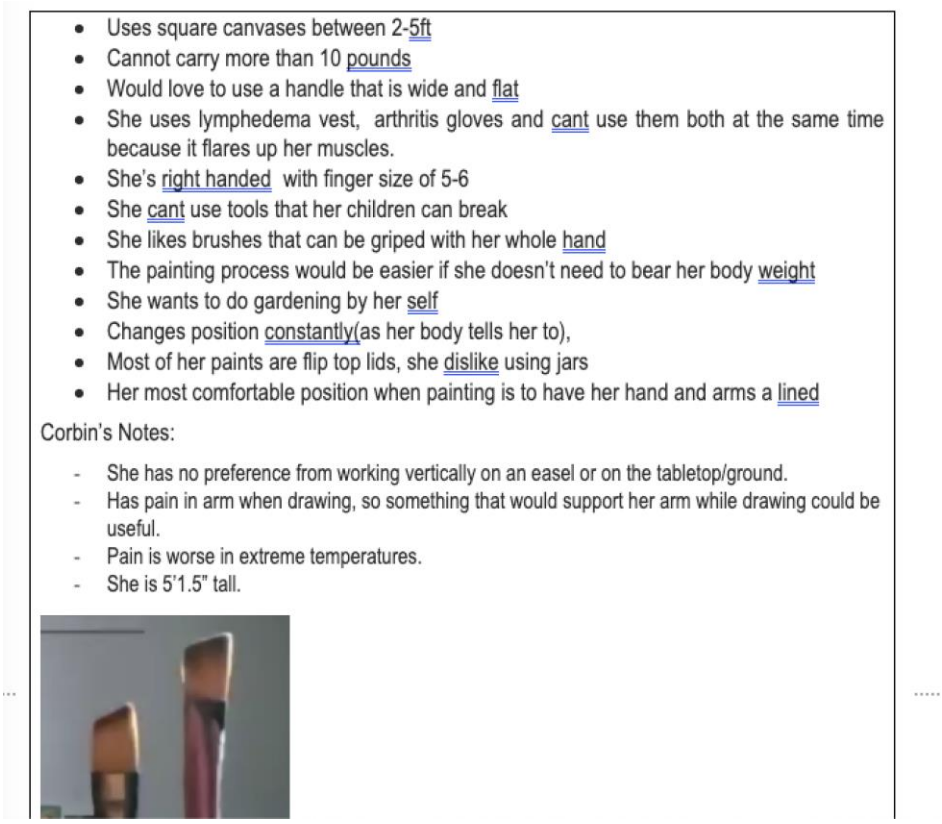
[2] Ansys GRANTA EduPack Software, GRANTA Design Limited, Cambridge, UK, 2020. (www.grantadesign.com)

[3] AutoDesk Inventor Professional 2021, AutoDesk, Inc, San Rafael, United States, 2020.

[4] Maddak Inc., *Ableware Universal Built-Up Handle (Pack of 4): Amazon.ca: Health & Personal Care*. [Online]. Available: https://www.amazon.ca/Ableware-Universal-Built-Up-Handle-Pack/dp/B00BSF7YC8. [Accessed: 13-Apr-2021].

Appendices

Section 1


- Uses square canvases between 2-5ft
- Cannot carry more than 10 pounds
- Would love to use a handle that is wide and flat
- She uses lymphedema vest, arthritis gloves and cant use them both at the same time because it flares up her muscles.
- She's right handed with finger size of 5-6
- She cant use tools that her children can break
- She likes brushes that can be griped with her whole hand
- The painting process would be easier if she doesn't need to bear her body weight
- She wants to do gardening by her self
- Changes position constantly(as her body tells her to),
- Most of her paints are flip top lids, she dislike using jars
- Her most comfortable position when painting is to have her hand and arms a lined

Corbin's Notes:

- She has no preference from working vertically on an easel or on the tabletop/ground.
- Has pain in arm when drawing, so something that would support her arm while drawing could be useful.
- Pain is worse in extreme temperatures.
- She is 5'1.5" tall.

Figure 1 – Consoliodated Client Notes

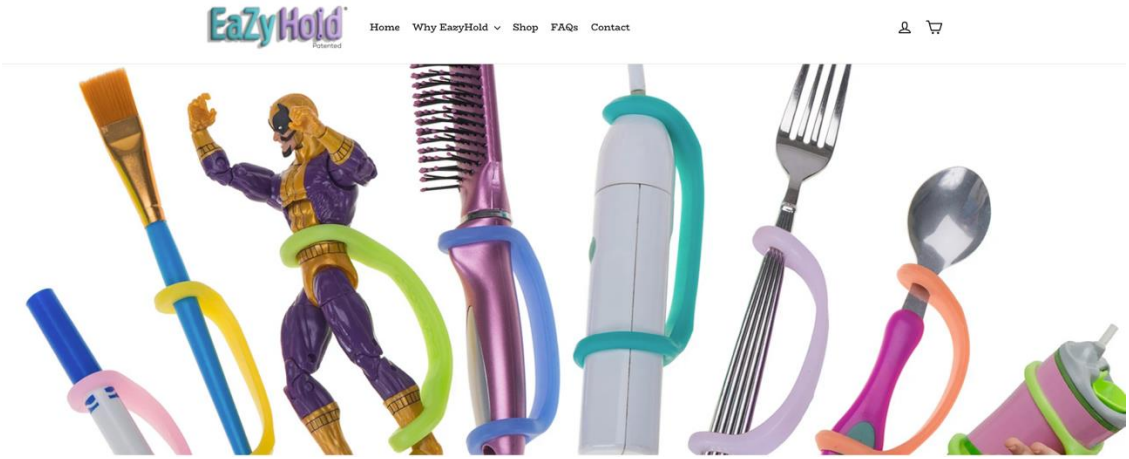


Figure 2 – EazyHold Universal Cuff

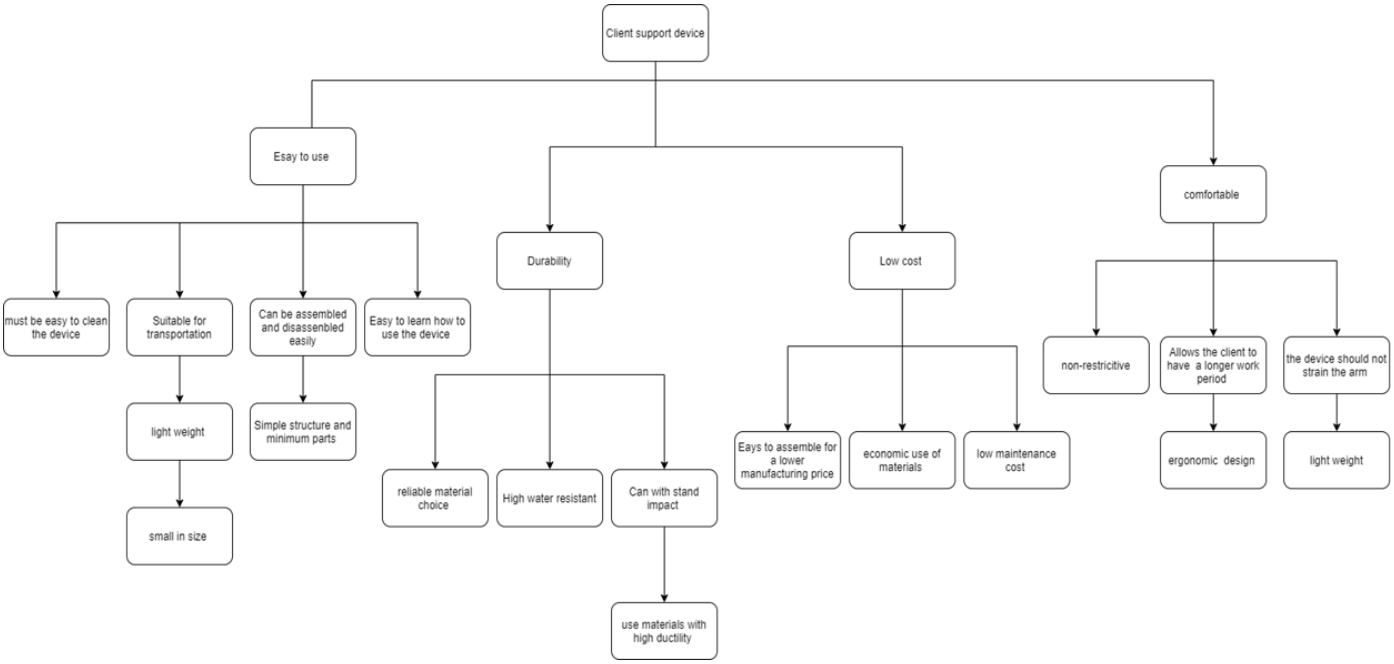


Figure 3– Objective Tree

Section 2

Function	Mean 1	Mean 2	Mean 3	Mean 4	Mean 5	Mean 6
Support her hands	Cane	Compression sleeves	Mahl stick	Brace	Strap	Exo-skeleton
Reduce fatigue and increase comfort	Padded matting	Modified workspace	Ergonomic stool	Back support with therapeutic magnets	Larger handles to grip	Actuator to help to bear weight
Increase arm strength	Exercising arm strengtheners	Outside force to help weight bearing	Robotic arm support	Arm-slings	Lifting system for heavy objects.	Grip texture to hold on to better.
Increase the number of tasks she can complete	Physical tool that will increase grip strength	Electric grabber	Leaning bridge	Flexible canvas	Pulley system	Comfortable material
Increase mobility	Use plastic material	Use fabric material	Use wooden material	Use rubber material	Wheels	Conveyer belt

Figure 4 - Morph Chart

Design a device that will assist Alaana to help support her in her physical needs and to maximize comfort. She needs assistance to help support her upper body movement. With this device, the client will be able to complete more tasks with less difficulty.

Figure 5 - Problem Statement

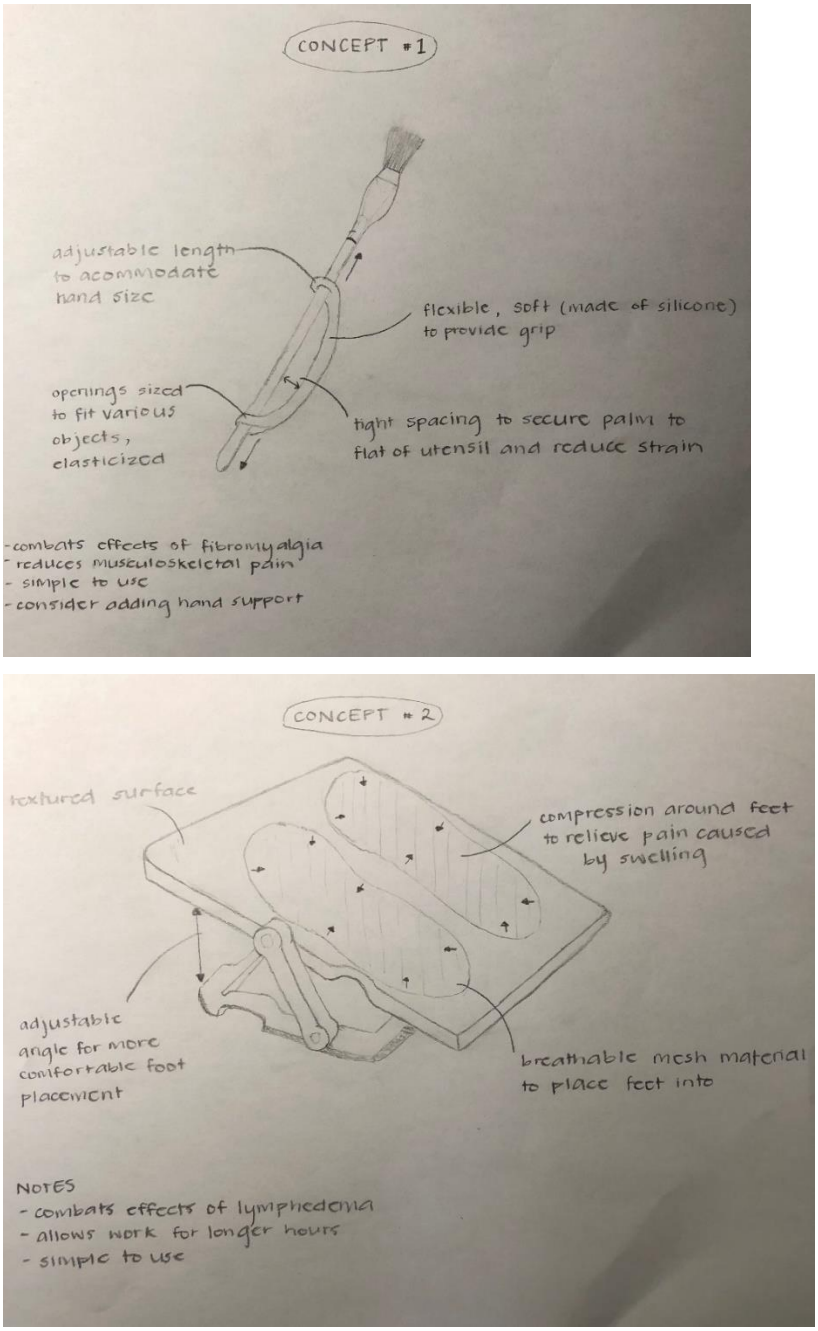


Figure 6 - 2 Concept Sketches by Aidan

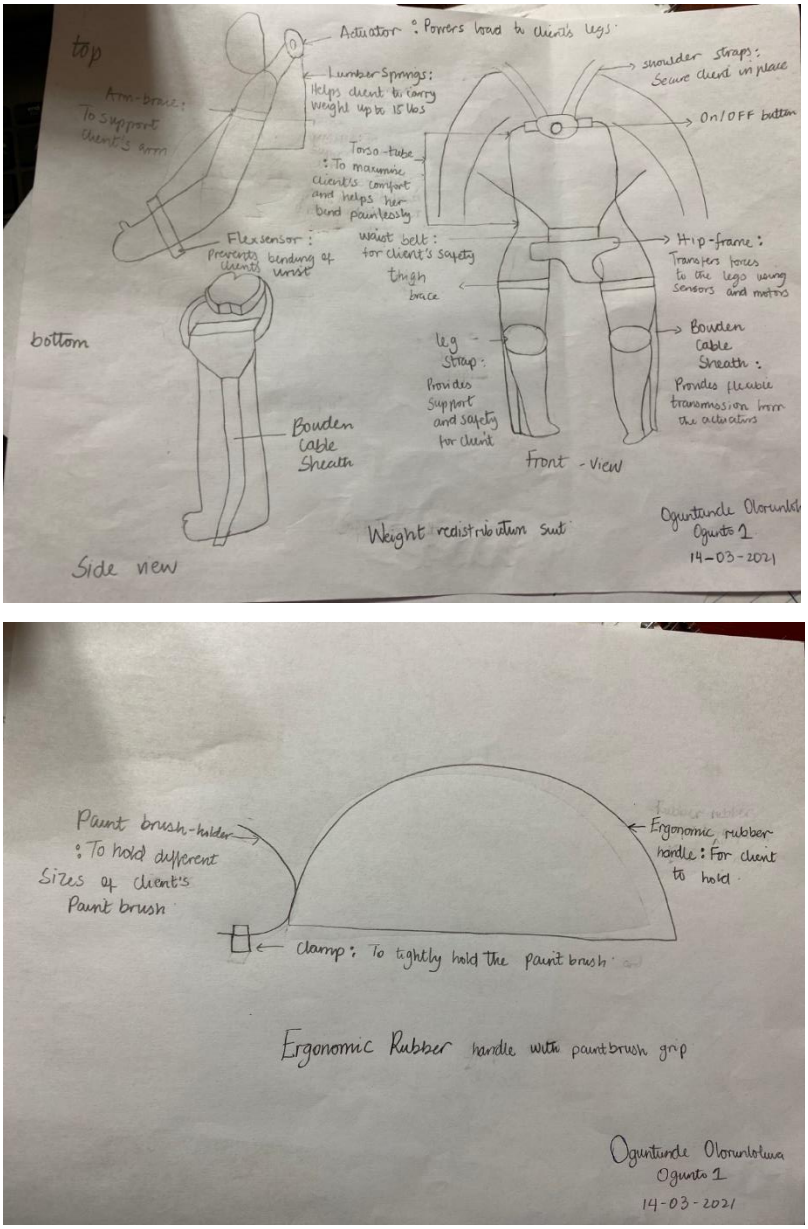
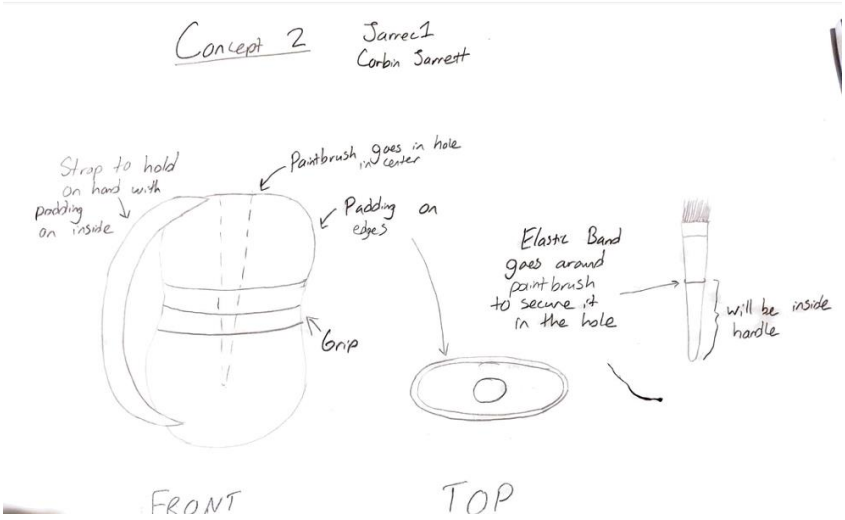


Figure 7 - 2 Concept Sketches by Lolu



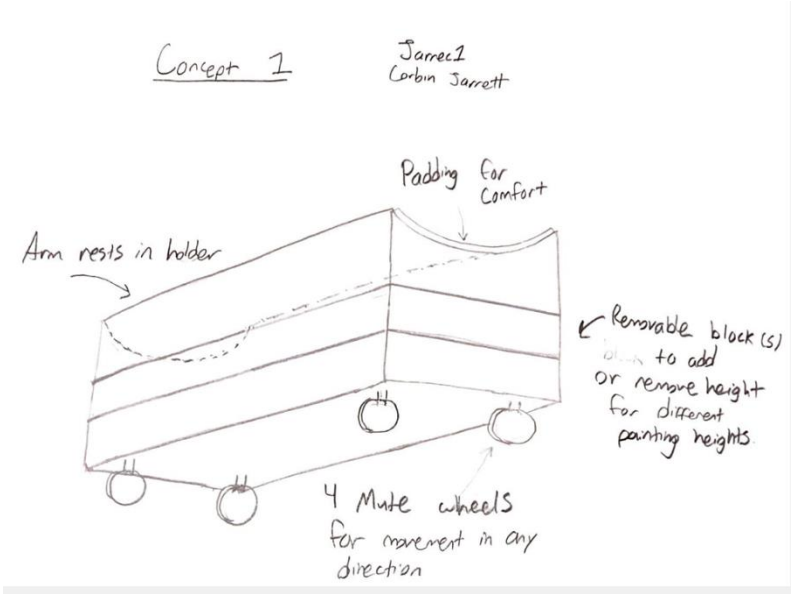


Figure 8 - 2 Concept Sketches by Corbin

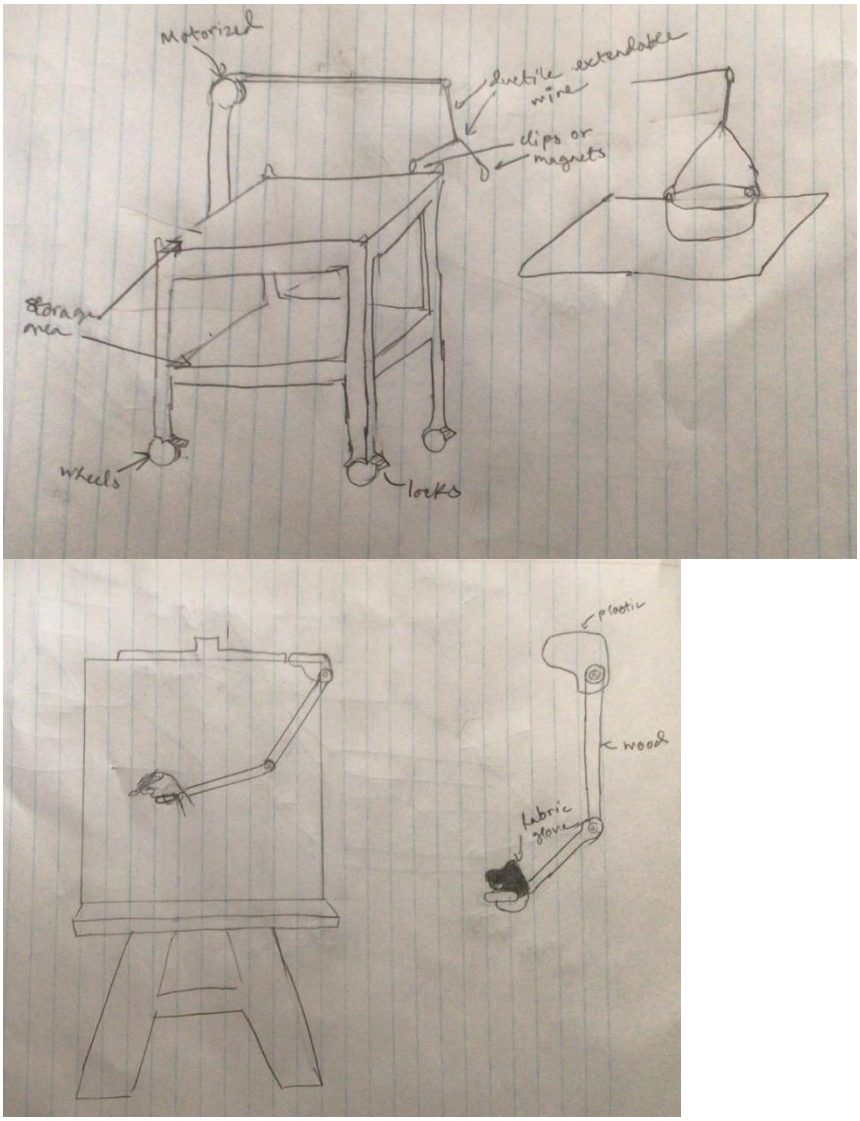
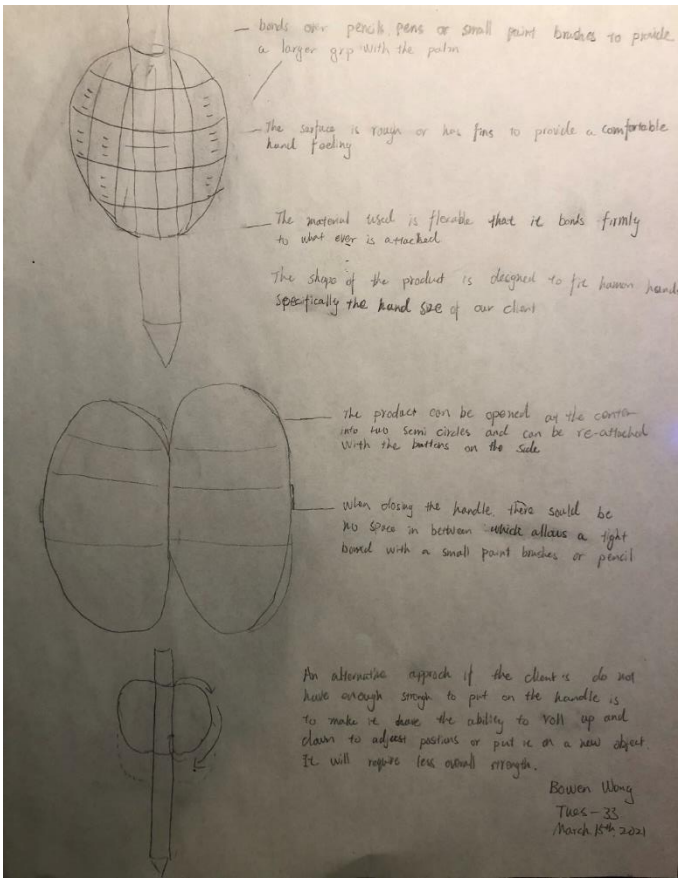


Figure 9 - 2 Concept Sketches by Zareen



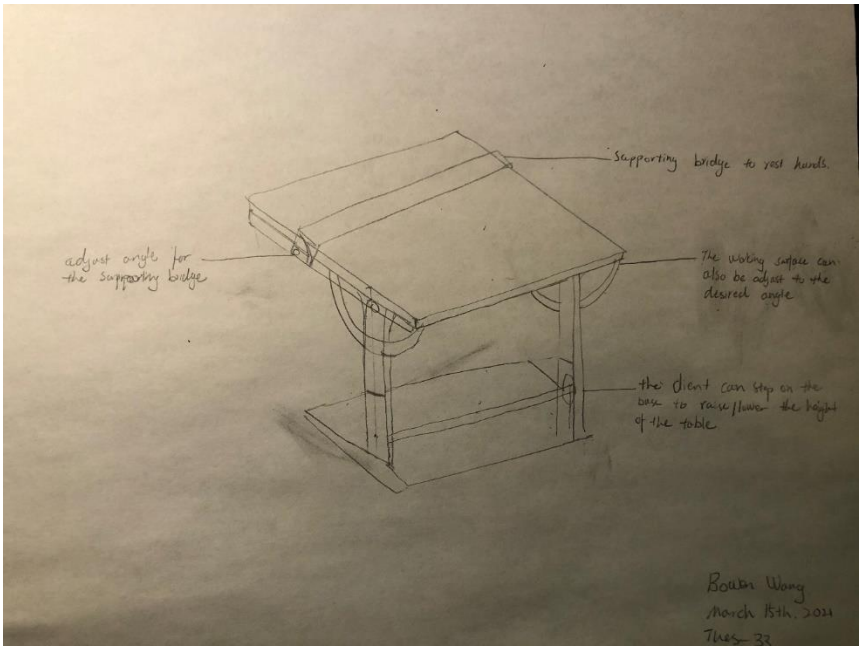


Figure 10 - 2 Concept Sketches by Bo Wen

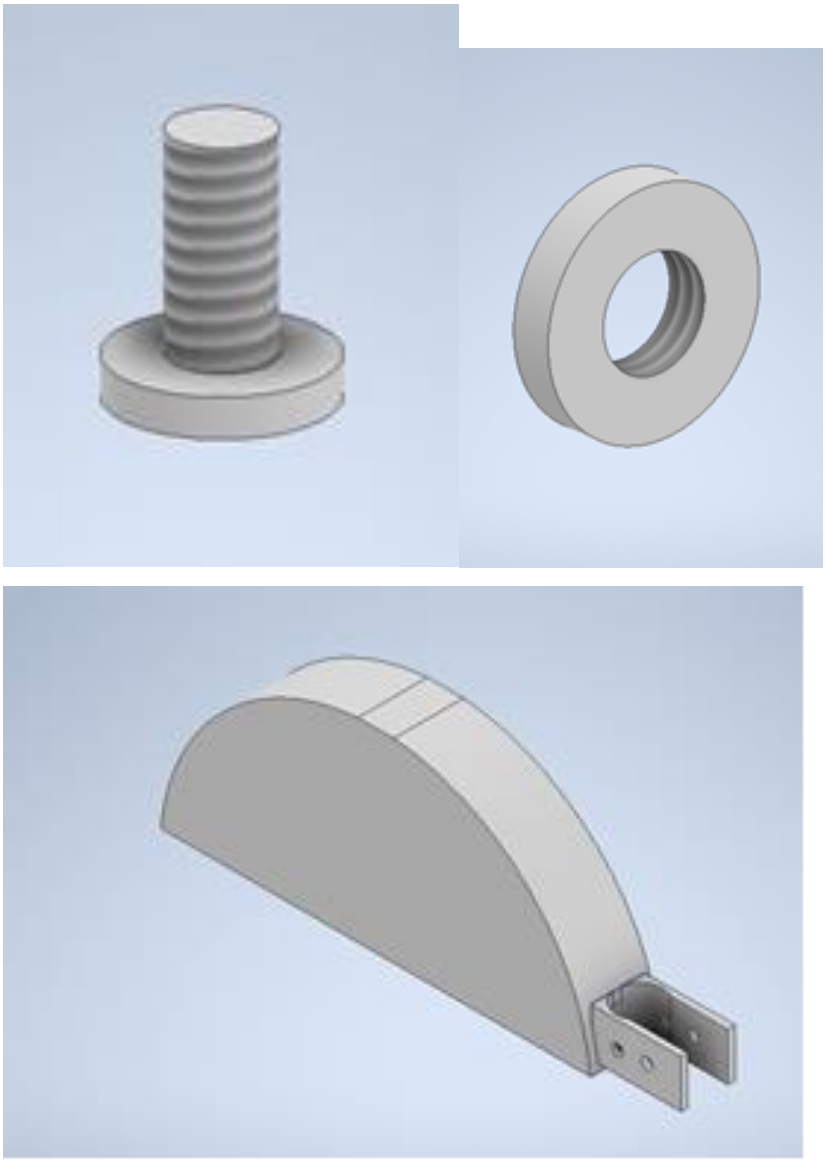


Figure 11 - Lolu's Prototype

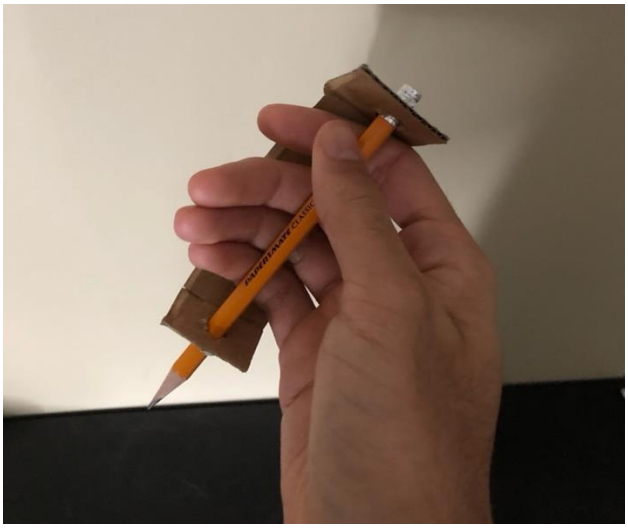


Figure 12 – Aidan's Prototype

Figure 13 - Zareen's Prototype

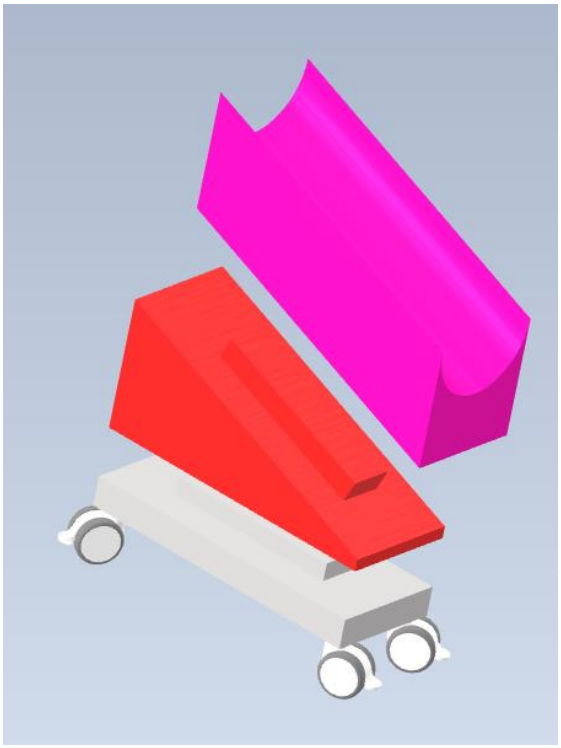


Figure 14 - Corbin's Prototype

Figure 15 - Bo Wen's Prototype

	Support her hands	Reduce fatigue and increase comfort	Increase arm strength	Increase the number of tasks she can complete	Durable	Easy to use	**Weight Factor**
Support her hands	1	0	1	1	1	1	**5**
Reduce fatigue and increase comfort	1	1	1	1	1	1	**6**
Increase arm strength	0	0	1	1	1	1	**4**
Increase the number of tasks she can complete	0	0	0	1	1	0	**2**
Durable	0	0	0	0	1	0	**1**
Easy to use	0	0	0	1	1	1	**3**

Figure 16 - Weighing Functions

Designs	*Flexible adaptive cuff with handle*		*Ergonomic rubber handle with paintbrush grip*		*Universal egg-shaped adaptive handle*		*Arm support on wheels*		*Mahl stick with attachment and resting ledge*	
Weight Factor	*Rating*	*Weighted Rating*	*Rating*	*Weighted Rating*	*Rating*	*Weighted Rating*	*Rating*	*Weighted Rating*	*Rating*	*Weighted Rating*
Support her hands	3	15	3	15	3	15	5	25	2	10
Reduce fatigue and increase comfort	3	18	4	24	3	18	3	18	3	18
Increase arm strength	0	0	0	0	0	0	0	0	3	12
Increase the number of tasks she can complete	4	8	2	4	5	10	2	4	3	6
Durable	5	5	3	3	2	2	3	3	2	2
Easy to Use	4	12	4	12	4	12	3	9	2	6
Total:	-	58	-	58	-	57	-	59	-	54

Figure 17 – Decision Matrix

	Insert your team's top two concepts below.
Concept 1:	Arm support on Wheels
Concept 2:	Ergonomic rubber handle with paintbrush grip

Include your team's justification below.

Based on the criteria that we chose for our decision matrix the two concepts had gotten the highest rating. Our choices in criteria were based on our morph chart that we had created in Milestone 2 and the Objective Tree that we had made in Milestone 1. We prioritize the criteria by comparing the necessity of each one against a different criterion and ranking them. After tallying up the ratings and weighing them appropriately the 'Arm support on Wheels' and the "Ergonomic rubber handle with paintbrush grip' had ranked the highest.

The Arm support on wheels was ranked very high in supporting her hands which is what made it do a bit better than all the other designs. Because of the long open tube, we decided that it would be a great resting place for the hands.

The ergonomic rubber handle did very well on reducing fatigue and comfort. It was a good shape for the client's hand and was exactly what she claimed she wanted in the interview. This will ultimately allow her to work for an extended period of time.

Figure 18 - Reasoning behind prototype choice

Include feedback from peers in this row.

The first design (arm holder) would be heavy and could fall on the ground.

- It might have an issue where it could roll into the canvas and cause a problem or roll off the table. The design is good but depending on how the client uses it, there could be negative effects.
- Good design but could use a strap to secure the client's hand better. Also, it would need to be light, or it would be hard to use.

The second design(Ergonomic handle).

- Screw might be difficult for the client to operate

Include feedback from science students in this row.

Arm Holder:

- Moving in the vertical direction could be difficult to stack blocks and then remove them for different angles. This is not efficient and should be changed.
- To solve the vertical problem, we could have an up and down mechanism.
- Use thermoneutral material and maybe foam to support her hands. This is a good idea because it is lightweight and super soft.
- 360-degree wheels to be able to move easier and in all directions.

Ergonomic Handle:

- Use thermoneutral material and maybe foam to support her hands and make it more comfortable and breathable
- Finger grooves to help with arthritic motion

Figure 19 - First Design Review Notes

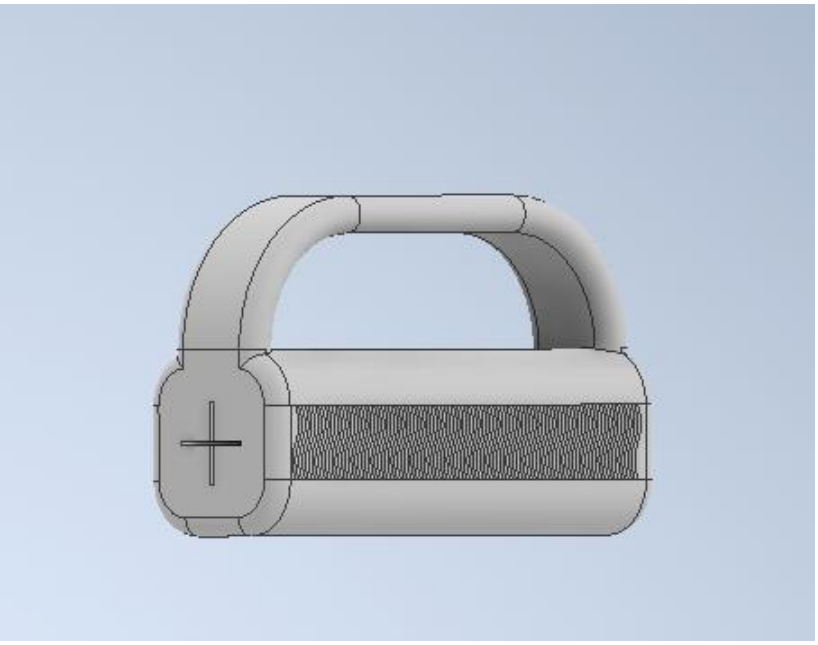


Figure 20 - Refined Prototype after Design Review 1

Include feedback from peers in this row. - The cross in the middle would need to be wider to hold larger objects. - Maybe add multiple sized crosses.
Include feedback from science students in this row. - Make sure when putting padding on make sure that the padding is in the design of how she normally grips the item, so it is easier for her to hold on. - Really professional, intuitive, makes sense. - Very versatile. - Would it work well for smaller objects, maybe make some different sizes. - Collection of handles - Maybe ask her to cut her paint brushes if they are too long. - Ask her how long her brushes are. - Watch out for paint in grooves. - Holding things can tend to be too heavy. Keep in mind making it light and portable. - Consider using thermoneutral material so that it can be held for a long time - Reduce thickness of handles - Use a flexible material (ex. Silicone)

Figure 21 - Feedback From design review 2

Section 3

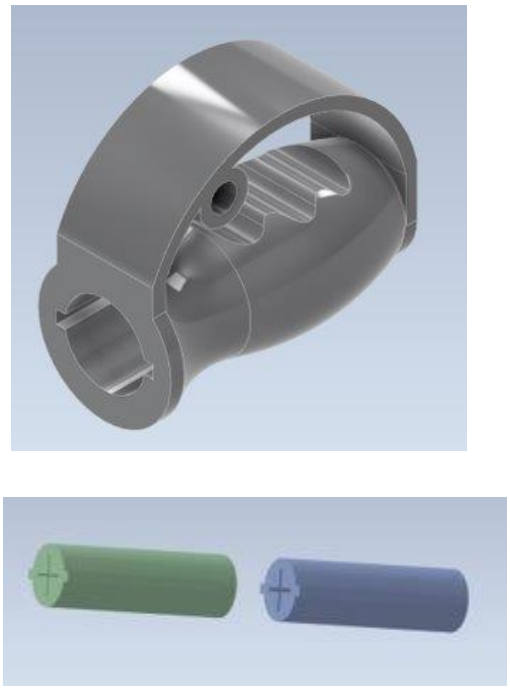


Figure 22: Finalised Prototype

Section 4

Preliminary Gantt Chart

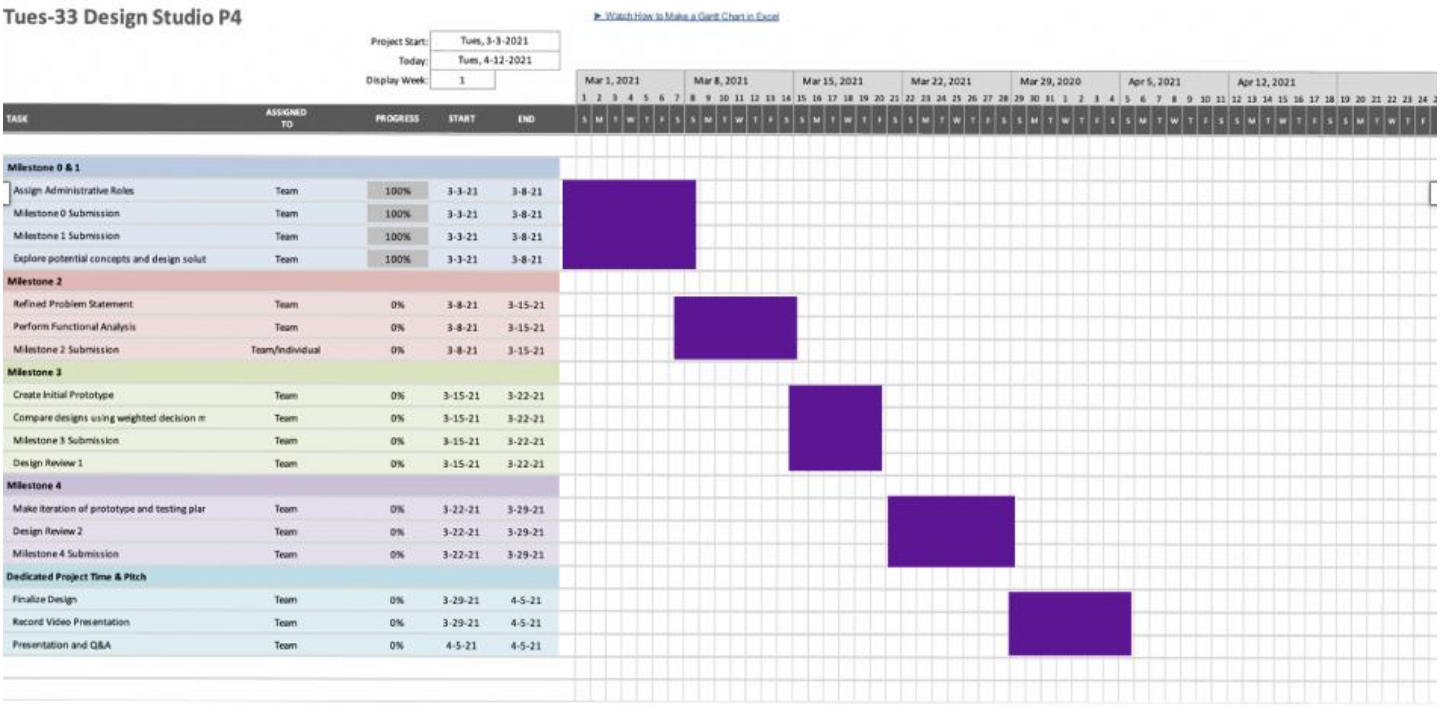


Figure 23: Preliminary Gantt Chart

Final Gantt Chart

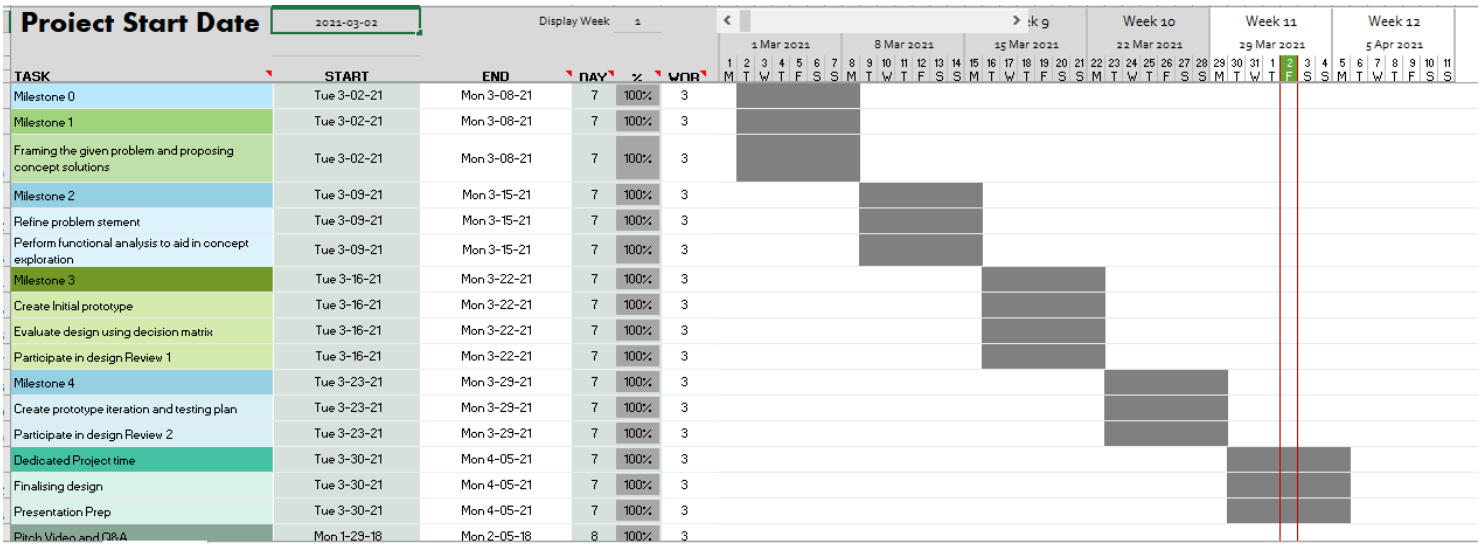


Figure 24: Final Gantt Chart

Logbook

- **3/13/2021(2 hours):**
  - **Members: Corbin, Bo, Lolu and Zareen**
  - Finish up Milestone 2.
    - Refine Problem Statement
    - Discuss potential ideas to prototype.
- **3/16/2021 (1 hour)**
  - Members: **Corbin, Bo, Lolu and Zareen**
  - Discuss Design Review and which prototypes to show.
    - Finish up Decision Matrix.
- **3/17/2021 (15 mins)**
  - **All members**
  - Design Review
  - Vertical motion should be improved.
  - Usage of thermoneutral materials such as foam on design #1
  - Design #2 inclusion of finger grooves to help in arthritis motion and desk chair wheels for a different design.
  - Paintbrush might have to be made smaller to use design #1

- **3/24/2021(15 mins)**
  - **All members**
  - Design Review:
  - Maybe a collection of handles
  - Weight of the handle
  - Designing size can be made smaller or lighter.
- **4/5/20201(1 hour)**
  - **All members**
  - Discussion of final design of our product
  - Meeting to record pitch video for our product.

Section 5

Source Materials Database

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