**Deliverable F - Prototype 2**

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October 9th, 2022

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# Introduction

In the previous deliverable, we presented prototype 2 to the client. It was a cushion that contains shredded foam and an acrylic plate backing with six snaps, placed at the corners and at the midway point between the snaps on the long side. Changes that were made from the initial conceptual design were implemented, such as the use of straps instead of Velcro. When the prototype was presented to the client, she was incredibly receptive to the ideas and changes. Based on the client feedback as well as feedback from the TA and PM, the project seems to be going in the right direction. At this point, the team is ready to test the prototype.

# Prototype II

In prototype 2, a physical prototype was developed. Some changes were also made to the prototype, the holes for the straps were moved towards the center of the piece and the dimensions were changed from 17” x 5” to 17” x 8”. This prototype consisted of the following parameters:

* Cushion containing shredded foam
* Rigid backing made of an acrylic sheet
* Snaps embedded in all corners of the sheet and midway between the corners on the long side
* A picture containing text

  Description automatically generatedBacking with holes cut into it where the straps will go
* Cover made of fabric

Figure Cushion case after sewing

A picture containing indoor

Description automatically generated

Figure Cushion case before sewing

Text

Description automatically generated with medium confidence

Figure Plastic backing after being cut from piece

A picture containing text, wooden, wood

Description automatically generated

Figure plastic backing with fasteners



A white pillow on a chair

Description automatically generated with low confidence

Figure Front of finished prototype 2

The figures above are pictures of prototype 2 during being made and put together, they also show how the prototype is held together.

# Prototype Testing Plan

Table 1

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Test ID** | **Objective** | **Description** | **Results** | **Estimated Duration and Timing** |
| 1 | Test the amount of pressure the cushion can support before total compression. | Incrementally add weight to the cushion, measure width | Width of cushion expands around an inch on either side when weight is applied. | About 5 minutes |
| 2 | Test speed with which the product can be assembled by one person. | One person who knows the method of construction assembles the prototype. They are timed. | Took around 15 minutes to assemble for the first time, 5 minutes the second time. | About 20 minutes  Repeat several times with different people |
| 3 | Test comfort of the cushion over long periods of time. | Use the cushion just above the shoulder blade for several hours. | Cushion provided comfort and excellent support for entire 30 minutes. | 30 minutes |
| 4 | Test the tension of the stitches in the cushion padding | Pull against the direction of stitching, gradually increasing force until a reasonable stopping point | Stitching done by hand on cushion cover separated easily. | 5 minutes, repeat as needed. |
| 5 | Test strength of steel fasteners | Attach cushion cover to the backing, pull on the cushion cover until it “pops” off. | All fasteners popped of when a somewhat large tension was applied in the compression cover. | 5 minutes, repeat as needed. |
| 6 | Test tensile strength of straps | Affix one end of a strap to an immoveable object, pull on the other end. Record length difference between taught and loose strap. | Straps did not stretch by any length or rip when tensile force applied. | 5 minutes, repeat several times. |
| 7 | Test buckle strength | Pull on the ends of a buckle until it “pops” apart. NOTE: this should not happen. | Buckle did not break apart. | 2 minutes |
| 8 | Test flexibility of acrylic plate | Apply torsional force to the acrylic backing, gently at first, and then gradually increasing force until a reasonable stopping point. | Backing is somewhat rigid but can still withstand moderate levels of torsion without failure occurring. | 3 minutes |
| 9 | Body-heat resistance | Place the acrylic in contact with a person for 20 minutes, record its temperature 1 minute after, 5 minutes after. | Temperature of acrylic changed very little after 20 minutes, and acrylic behaved the same. | 25 minutes |
| 10 | Test the tension of the stitches in the cushion cover | Pull against the direction of stitching, gradually increasing force until a reasonable stopping point | Stitching did not separate much, because the stitches were done with a sewing machine. | 5 minutes |

After testing our second prototype, the main areas of improvement would be the stitches on the cushion and the speed of product assembly. The main problem with the assembly has to do with the design of the compression cover. The design is messy and complicated, which is certainly not what we would like to have on our final design. This was because none of us had any experience using a sewing machine before, we now have a better idea of how to use it. Because we do not need to purchase any more foam, we have enough money to purchase new fabric and come up with a better design for the compression cover. The cushion cover will be remade as well with our new fabric and will be sewn with the sewing machine rather than by hand to improve the stitches.

# Client Statements

During our third client meeting we came up with our first prototype with slight changes made on it. We used straps instead of Velcro to attach the cushion to the chair, we added an attachment mechanism to fasten the cushion to the backing, and we used acrylic sheet instead of PLA filament for durability and flexibility. And when we presented that to our client, what we were able to collect from her feedback is that she prefers the straps instead of Velcro and that she would like to have soft foam with no hard pieces, because hard objects are more likely to cause dislocation. We have also noted that she likes the shredded foam and that she would like the cover of the cushion to be red. She let us know that she likes compression cover and prefers acrylic backing as well. So based on what our client said and what we have been able to come up with, we can say that we are gradually approaching our client needs. However, everything is not perfect yet and changes and/or improvements still need to be made in our design such as the colour of the cushion’s cover, and the sewing on both cushions for example.

# Previous Prototype

Our last prototype was analytical and consisted of a modular backing design that would’ve been 3-D printed. After a very insightful conversation with a teaching assistant during the lecture, we decided that this may not be the best route to take. Although the modular design was innovative and creative, it was not practical for everyday use. We also realised that the size of the 3-D printers would prevent us from creating the modular design we had originally planned on using. We are now using a 1/8’’ thick piece of acrylic as the backing, which can conform to the curvature of the clients back just like the modular design.

# Critical Product Assumptions

Now that we have our first physical prototype, we’re able to define any new critical product assumptions much more easily. Our new assumptions include the following:

1. After our discussion with a TA during the lecture, we’re assuming that our acrylic backing for the cushion is the better option for our backing design. We had originally planned to 3-D print a modular design and fasten it together. Due to the size of the 3-D printers available to us, and our goal being to create a user-friendly prototype, we decided to go with the acrylic backing.
2. Now that all the parts we have ordered came in, we have assumed that we now have all the parts we need for our final prototype.
3. After testing our shredded foam cushion and showing it to the client, we have assumed that we no longer need to purchase any more foam to make the cushion.
4. We have assumed that the acrylic backing will be able to withstand the force of the client’s body without breakage.
5. We have assumed that the snaps that attach to the outer cover will not rip the cover. We will reinforce the corners with snaps with extra fabric to ensure it doesn’t rip.
6. We have assumed that the snaps attaching the backing to the outer cover are strong enough to withstand the force of the client’s body without breaking.
7. We have assumed the acrylic is strong enough to withstand the force from the snaps without breaking.
8. We have assumed that the straps will be able to tighten and loosen without any ripping.
9. We have assumed the buckle on the strap is strong enough to withstand the force of the tension in the strap.
10. We have assumed that the width of the cushion when compressed does not exceed the width of the wheelchair.
11. We have assumed that the body temperature of the client will not affect the behaviour of the acrylic to a high degree.

# Conclusion

In this deliverable, a physical prototype was developed. The team assembled a plan to ensure that all the factors that need to be tested will be tested in the next deliverable. The prototype was also shown to the client and feedback was received. The fabrication of the prototype resulted in the ability to assemble a list of critical product assumptions. The team has begun buying new fabric for the cover and plan on getting better at using the sewing machine. Additionally, the team plans on getting better at completing tasks on time and being more efficient during the times when they are working. They have also decided that they are not punching holes for the snaps till new case complete.

# Wrike Snapshot:

PD-G Plan: <https://www.wrike.com/frontend/ganttchart/index.html?snapshotId=hHO8BiG2FyLzbcsVTyBImNTBdgKjj3cO%7CIE2DSNZVHA2DELSTGIYA>

Prototype 3 Plan: <https://www.wrike.com/frontend/ganttchart/index.html?snapshotId=EtgJJAnKyGt38NXG0tDGGijxOEG7llCB%7CIE2DSNZVHA2DELSTGIYA>

PD-J Plan: <https://www.wrike.com/frontend/ganttchart/index.html?snapshotId=Kv2NmfrFdiW5oPZ4OTUlnBKD2i55rlae%7CIE2DSNZVHA2DELSTGIYA>