ENGINEERING

McMaster University

Project 4 – Project Reflection

ENGINEER 1P13 – Integrated Cornerstone Design Projects

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Tutorial 07

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Throughout the course of Project 4: Power in Community, I was a part of a team given the task to come up with a solution to make the client's daily living better by mitigating any roadblocks that restrict her from taking part in her daily activities [1]. After exploring the client's difficult tasks, we compared our combined notes from the client visits and decided to focus on designing a device to tackle her struggles with lymphedema, which refers to the associated swelling that occurs due to the interruption of regular flow in the lymphatic system (usually due to the removal and/or damage of lymph nodes when undergoing treatment for cancer) [2]. I am highlighting two main processes: the decision-making and ideation testing process. The decision-making process was initiated with the concept exploration stage, which after narrowing down our top objectives, we built numerous concepts within our design space, which is defined as "the set of all possible design alternatives that fall within the design constraints" [3]. Relative to the process, the decision we made as a team pertained to narrowing down the numerous concepts present in our design space to our current final design. One of the decisions we had to make was deciding which of our eight initial concepts would best fit our problem statement and be the most practical design in terms of aiding the client. The steps taken to narrow down our top concept idea included using functional analysis, which refers to a creative design process that focuses on design function rather than physical form [4]. We utilized a morphological chart and a weighted decision matrix to narrow down our concepts, which can be seen in Tables 1 and 2, respectively.

Table 1: Morphological Chart

Functions	Means				
Bears Load off Joint	Lever	Wheelchair	Using a custom brace	Rollers that conduct manual lymph drainage	Cane/Walker
Easy to Grip	Flat, wide handle	Gauntlet that wraps around hand	Flexible handle that fits around hand	Custom gripper that fits around objects	Gripper glove
Provides support for dominant arm	Moving arm rest/stand	Flexible arm sling	Portable dynamic connecting arm brace that mounts to any surface	Soft, heating wrist splint	Vest with arm support structure
Reminds Client to Take Breaks	Coded timer	Pressure sensor in body	Coded reminder app	Coded app to create a schedule to avoid overworking your body	Coded tracker app (in terms of fitness or activities)

Table 2: Weighted Decision Matrix

	Weight	*Manual Lymph Drainage Arm Brace*		*RemindMe! App*		*Forearm Lifter*		*Dynamic Arm Brace*	
		Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating
Lightweight	3	5	**15**	3	**9**	4	**15**	1	**3**
Cheap to produce / manufacture	2	4	**8**	3	**6**	5	**10**	2	**4**
Durable	4	2	**8**	2	**8**	3	**12**	3	**12**
Aesthetically Pleasing	2	3	**6**	5	**10**	1	**2**	1	**2**
Adjustable	5	4	**20**	1	**5**	2	**10**	4	**20**
Bears load off arm	5	1	**5**	1	**5**	4	**20**	5	**25**
TOTAL			**62**		**43**		**69**		**66**

The criteria we used to narrow down our concepts consists of accumulated objectives based off of two client visits with Alanna, which highlighted the numerous roadblocks she had come across as well what she envisioned in the product for her benefit. From this feedback, we were able to narrow a concept that we felt would fit all criteria and be the most helpful long-term aid for the client. Keeping an open mind during the design process

allowed us to uncover a unique solution after the first design review, where we showcased three of our prototypes, two being physical and one being a software approach. From the associated feedback, we combined all of our concepts into one final design instead of going with the software approach as it was infeasible in the time given. As my main priority focused on the software approach, the combined perspectives from the feedback allowed me to pivot and realign my goals. Specifically, I understood that their feedback was not a reflection of the idea but rather the feasibility, which I then started to take into context. As a team, we brainstormed methods to combine our concepts to form our next proposed design prototype. With confidence in one of our initial prototypes, a manual lymph drainage arm brace, we added an old concept from our morphological chart which was a dynamic arm rest, and combined the two to form our present design solution. After iterating through the numerous stages throughout project 4, we reached a consensus for our final design to be a manual lymph drainage arm brace with a dynamic arm rest. Our initial sketch, prototype, and final design can be seen in Figures 1, 2, and 3, respectively.

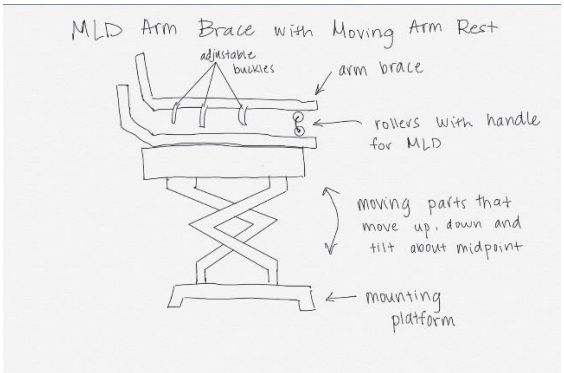

Figure 1: Initial Sketch of our Concept

Figure 2: Preliminary Prototype

Figure 3: Final Model of Proposed Design Solution

After attending our second design review, we gained a lot of positive feedback from the reviewers, which consisted of suggesting a multifunctionality aspect to our design. We received feedback to enable the two concepts to be detachable, allowing the arm stand to be a device on its own, in addition to ensuring that the design does not have any sharp edges to harm the client. This design review gave us more confidence with our design and reassured us that our team was on track, especially with the help of continuous feedback to help guide us. For testing, we had three main methods to test our prototype with the provided resources. This included testing our top objectives of safety, ease of use and how lightweight the design was. To test for the safety of our design, we tried to mitigate all sharp edges in the design that may cause flares for the client's autoimmune diseases. We decided to test this through observations of the model in Inventor and adjusting as necessary. To test for ease of use, one of my team members developed a motion demonstration in Inventor to showcase how the device could be easily used. This was in addition to testing a physical version of our initial prototype on another individual to see how easy it was for the "fake" client in this case to use the prototype. The motion demonstration can be seen in Figure 4 below.

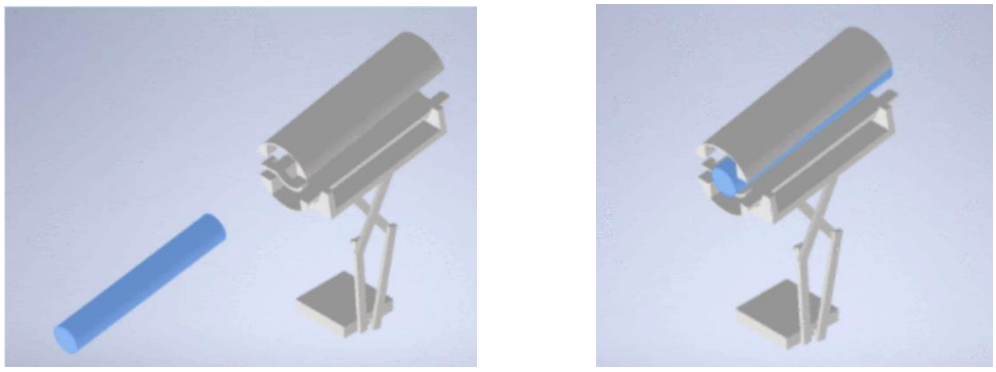

Figure 4: Screenshots of stages of motion demonstration

To test for our final objective to determine if the design was lightweight or not, the device had to be within the range of 5 to 10 lbs (the manageable weight mentioned by the client) [5]. With GRANTA, we estimated the total amount of each material needed to construct our device and calculated the total cost and weight with that estimation, which determined that the weight was effectively within the range. All three aspects of our test plan aided in determining the effectiveness of our objectives. However, an optimal test plan would have included testing our finalized prototype with the target client with adjustments based on their feedback. This was one aspect that was difficult to test in a virtualized manner. Given these circumstances, I believe that our test plan provided us a good base to check performance. At the final stages of our project, having completed all the steps necessary to successfully design our device, I am proud of what we have to present as our final design solution. The manual

lymph drainage arm brace with a dynamic arm rest is a new path to independence for the client, and we hope that she loves the device as much as we do.

Feedback and iterations of the design process posed numerous challenges and successes throughout this project, but we learned a lot as a whole. For instance, the main challenge for our team consisted of the fact that testing a design in a virtual setting was much harder than we had anticipated. Although testing our objectives using Inventor, GRANTA and our own observations were helpful, in reality, objectives such as ease of use are harder to gage without in-person testing with a physical prototype. Another challenge was in regards to the resources used to build the prototype, which may have been facilitated with better resources and testing on the client rather than at home with ourselves. One way we adapted towards this problem was by asking as many questions as possible with Alanna to gage her preferences for certain aspects of our current design. For instance, Alanna had mentioned that due to her autoimmune diseases, her skin is easily agitated, thus leading to her wearing a lot of items made out of silk or cotton. This led us to revise our current design by adding a thin cotton lining on the inside of the arm brace to accommodate for this. Additionally, in order to imitate in-person feedback, we asked the client of her arm measurements to adjust the dimensions of our model in Inventor to make the device specific for her. I believe this experience of coming up with a virtual test plan was important, although difficult, especially for myself, as it forced us to think about all the aspects of the design from the client's perspective. It allowed us to question whether each objective was practical to be represented in the device. Thus, as a whole, the listed challenges allowed us as a team and as individuals to learn from our mistakes, and pivot our strategy to create an optimal design and learn troubleshooting tactics. Some of the successes we came across through our project all occurred around the time we finalized our design. After our final design review, with a few suggestions, our design was everything we imagined it to be and more. This point in our engineering design process pinpoints the exact time in which we, as a team, felt as though we had successfully come up with a practical design that could be of use to the client. Although at times, the iterating process of redesign and development may have been overwhelming, the potential of our device to aid the client with her struggles from lymphedema made it all that much worth it. Additionally, I view a lot of the design reviews as successes on their own as they aided us in reaching our final design, and if it were not for both of those design reviews, we would not be on track at all. I am very thankful to have had the opportunity to gain feedback from numerous perspectives and I can see how much of an impact it has made after comparing our initial concepts to our final proposed design solution. These examples mentioned above of both the challenges within the ideation testing stage and the successes of coming to a consensus on our final design through the aid of the numerous iterations of the design process were a key part in my learning as they allowed for the growth of our team. A huge takeaway I gained is I now know how to

appropriately take feedback in a positive manner and work with it rather than letting frustration get the best of me. I believe a huge lesson learned in this project was how to incorporate multiple perspectives from the numerous TA's and professors with our own perspectives and goals. I learnt to view feedback from a team-based perspective and that professors and TA's simply have the same goal as we do, to help us come up with a design solution to the best of our abilities to help the client. My perspective of feedback has changed tremendously, and although I was able to receive feedback in a positive manner before this project, the numerous iterations of reviewing our design made it more overwhelming this time around, but it allowed for a huge learning process in the end for myself.

Through the experiences of both testing ideas and coming to a final design solution, I have learned a lot about the engineering design process, specifically the importance of pivoting and design iterations during development. This final project being very open ended allowed us to use all the skills we have built thus far, and I feel as though I learned a lot not only from my teammates but also from our TA's and professors about the engineering design world. This project allowed for a small glimpse into the real-life engineering design process, and it reassured myself that helping people through design is exactly what I aspire to do. I have gained numerous skills from this project, but I think I have gained the most in terms of growth in both an academic and interpersonal sense. Some of the new learnings I have discovered is how important both the numerous iterations as well as feedback plays in the engineering design world and the vital role they play towards the final design. For instance, for our design, if we had not taken the feedback from both the design reviews and any additional feedback from the professors or TA's, we would not have the design be as effective as it is presently. Feedback and numerous iterations have allowed us to perfect our product in places we did not see an issue, which would have not been possible without the issue being brought to our attention in the first place. From this, we as a team were able to utilize that information, address the issue, and develop a solution for it to produce an improved design solution to ensure that the client will be able to utilize our product in the best form. I plan to keep both the new perspective of feedback and the importance of iteration with me for a lifetime. It has definitely proved to make a huge impact in this project, and I will continue to strive to get as much feedback as possible, especially from those with experience in the background of the project and without. I have seen the impact of feedback in this project from individuals with numerous backgrounds in their fields, and it aided a lot to have a variety of perspectives and input. I am very thankful for that and as a result will always seek to find any sort of feedback in my future projects.

References

[1] “P4 Project Module,” class notes for 1P13, Department of Engineering, McMaster University, Winter, 2021.

[2] “Lymphedema – Symptoms and causes,” Mayo Clinic [Online]. Available: https://www.mayoclinic,org/diseases-conditions/lymphedma/symptoms-causes/syc-20374682. [Accessed: April 10, 2021].

[3] “Lecture 51, March 8th – Review from Conceptual Design to Prototyping,” class notes for 1P13, Department of Engineering, McMaster University, Winter, 2021.

[4] “Lecture 13B - Oct. 28th – Functional Analysis (UPDATED),” class notes for 1P13, Department of Engineering, McMaster University, Fall, 2020.

[5] “Mar. 10th Client Visit Q&A,” class notes for 1P13, Department of Engineering, McMaster University, Winter, 2021.