



Design Project 4 – Not a Pun, It’s Real Life

THE TOPOGRA-FIT

IBEHS IP10 – Health Solutions Design Projects

Tutorial 05

Team 35

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Table of Contents

Academic Integrity Statement	3
Executive Summary	4
Main Body.....	5
Summary of Design Objectives	5
Background and Research Summary	5
Description of Proposed Solution	6
Product Identification.....	8
Usage.....	8
Standards and Safety	9
Appendices.....	10
Appendix A: Project Schedule	10
Appendix B: Scheduled Weekly Meetings	12
Appendix C: Design Studio Worksheets.....	17
Appendix D: Comprehensive List of Sources.....	26
Appendix E: Additional Documentation.....	27

Academic Integrity Statement

The student is responsible for performing the required work in an honest manner, without plagiarism and cheating. Submitting this work with my name and student number is a statement and understanding that this work is my own and adheres to the Academic Integrity Policy of McMaster University.

Elias Taylor 400388518

X Elias Taylor

The student is responsible for performing the required work in an honest manner, without plagiarism and cheating. Submitting this work with my name and student number is a statement and understanding that this work is my own and adheres to the Academic Integrity Policy of McMaster University.

Emeline Bespalov 400396802

X Emeline Bespalov

The student is responsible for performing the required work in an honest manner, without plagiarism and cheating. Submitting this work with my name and student number is a statement and understanding that this work is my own and adheres to the Academic Integrity Policy of McMaster University.

Spencer McLean 400394520

X Spencer McLean

The student is responsible for performing the required work in an honest manner, without plagiarism and cheating. Submitting this work with my name and student number is a statement and understanding that this work is my own and adheres to the Academic Integrity Policy of McMaster University.

Mattia Solenka 400370335

X Mattia Solenka

Executive Summary

Multiple Sclerosis (MS) is a debilitating disease that entails muscle weakness and mobility issues, often forcing individuals to make lifestyle changes to adapt to their new limitations [1]. Some of the most common symptoms are weakness in the limbs and a lack of coordination [1]. For our client Nadina Gregory specifically, these symptoms have particularly impacted her right hand, forcing her to complete many of her daily tasks with her non-dominant left hand. Particularly for daily self-care tasks such as doing makeup, this has posed challenges in terms of her ability to grip items like makeup tools and hairbrushes, and use them for extended periods of time. The goal of our device is to facilitate a more comfortable and sustainable grip when holding small items, so that Nadina is able to comfortably and securely use them independently for extended periods of time without fatigue.

In this report, our team will outline the design process and final solution synthesized with specific intention to help Nadina Gregory complete personal care tasks, such as brushing teeth and applying makeup, all things identified through an interview process as challenges for Nadina. On top of having to deal with the struggles of using a non-dominant hand in her daily tasks, Nadina's left hand has also been affected by multiple sclerosis, although to a lesser degree than her right hand. This gave our team a clear target for the design of a supportive device that could help Nadina re-establish independence in her daily tasks, while building on her current strengths and not taking any control or current ability away.

Thus, the Topogra-Fit, a glove with the ability to be slipped on with one hand, that builds upon the natural of topography of the hand to lower the strength, precision, and dexterity needed to grip objects in the hand, was synthesized. Stemming from a desire to build on the abilities Nadina already possesses, the topographical grip attached to the fingerless glove allows for Nadina to use her left hand to pick up small objects – specifically longer, cylindrical-shaped objects – as they slot in between the ridge at the base of the thumb area and the complimentary ridge at the base of the fingers. Then, with the rubber grips in the valley of the ridges, objects can be securely held with little applied force, instead being held by friction. For Nadina, this will allow a clear increase in ability to use the items she needs to, with the hand she can use them with. In tandem with a system that allows the glove to be slid on and off without any assistance, the Topogra-Fit is the perfect fit for Nadina, and all those with a need for increased comfort in using their non-dominant hand, or a need for increased grip strength. With the Topogra-Fit we believe that Nadina, and many others like her, can reclaim a sense of independence in their own lives through the small personal tasks they do every day.

Main Body

Summary of Design Objectives

Need Statement: Design a device for Nadina that helps her accomplish daily tasks made difficult due to muscle weakness caused by multiple sclerosis, while maintaining a sense of independence.

Customer Requirements:

1. This solution should work long term as well as short term, meeting changing needs (objective)
2. This solution should be user-friendly, able to be operated by Nadina alone (objective)
3. This solution must meet safety regulations and standards (constraint)
4. This solution must not impede Nadina's independence of motion (constraint)
5. This solution should be portable, at least within the house (objective)
6. This solution needs to support the function of her right arm and/or hand (function)
7. This solution needs to reduce the physical exertion required to perform daily tasks (function)

Background and Research Summary

While over 2.8 million people live with multiple sclerosis (MS) worldwide, very rarely do we get the chance to make a difference for even just one person [2]. Fortunately, with Topogra-Fit, we are able to help Nadina Gregory accomplish daily tasks made difficult due to muscle weakness while protecting her sense of independence. Our product is far ahead of the competition thanks to our rigorous research, background in design, and in-depth consideration of MS in both the general case and for our client.

The research for Topogra-Fit began with the interview we conducted with Nadina in the design studio at the beginning of Design Project Four. From the beginning we prioritized asking questions and taking notes based on the most important details of her life with MS. We learned about Nadina's poor muscle control in her dominant hand which left her independence, one of the things she values most, in jeopardy. The Topogra-Fit would be designed around returning this sense of normality and independence into her life by assisting her in daily tasks such as applying makeup, which she consistently spoke of as an enjoyable activity. Only two weeks into the project, we had already formed a strong basis for idea generation and product creation.

We would quickly build upon this basis by performing more general research into MS as a condition. This provided us with additional insight about her condition as well as what a long-term solution would look like. Since MS is a progressive disease that both increases in severity and spreads throughout the body, we knew we needed a solution that would be usable both now and in the future. To this end we began implementing a glove design based around holding items, ensuring it was comfortable and unobtrusive, allowing it to be worn for extended periods of time and used as much as possible while preserving independence. This caused material choice to lean towards soft fabrics, with the inclusion of mouldable loops used to hold a variety of products, constituting a design centred around one-handed operation. This product would ultimately help both the average MS patient suffering from loss of dexterity and poor mental health because of dependence, as well as Nadina herself.

However, no product would have been made without our background skills. Thanks to our group's excellent sewing abilities we were able to construct a working prototype easily by modifying an existing glove. This would then be improved further through the addition of more complicated components such as the palm

pad made of pipe cleaners sewn into a fabric case. This ability to easily progress from idea to prototype was our most valuable asset during this project.

By exploring all avenues of research regarding MS and Nadina herself as well as taking into consideration our background knowledge and skills, we successfully created a product to assist in daily tasks while retaining a sense of independence. Topogra-Fit is the premier product to handle MS and reduce the physical hinderances that Nadina experiences in her daily life.

Description of Proposed Solution

Our design – the Topogra-Fit – consists of a wearable hand device with a mouldable grip component sewn into the palm, allowing Nadina to hold small objects, such as makeup tools and products, in her left hand without requiring excessive pressure or strength from her hand [Figure 1]. The mouldable grip on the palm consists of a shaped mass of bendable wiring (pipe cleaners in our prototype), with fabric sewn over to create a more cushioned hold [Figure 2]. The grip is shaped as two outer ridges with a groove in between, and this is where objects can be slotted and held in place. This grip allows small objects of different shapes to be held firmly in the grip, as it can mould around whatever is in the palm. Additional important features of our device include textured rubber strips along the groove in the palm for a better grip, as well as a little finger hole that helps ensure correct and anchored positioning of the wearable [Figure 1].



Figure 1. The Topogra-Fit



Figure 2. Mouldable grip separate from glove base

Our wearable device is also able to be put on and taken off with only one hand, using a mechanism that involves a plastic strip sewn along the wrist of the wearable - a strip that is able to slot into a pair of command hooks that can be mounted on any surface. [Figure 3] The plastic strip slotting into the command hooks provides the resistance needed to pull the device on or off with only one hand. [Figure 4] This is important considering Nadina's lack of strength and mobility in her right hand. This also contributes to our goal of maintaining Nadina's independence, as this would allow her to use the device entirely on her own.



Figure 3. Close-up of plastic strip for device application



Figure 4. Demonstrating use of command hooks and plastic strip for device application

This device will address the problems presented by Nadina's lack of coordination and strength in her left hand, as this is her non-dominant hand and while it is not as impaired by her MS as her right hand, it is still weaker than normal. Having a grip that is able to mold around objects in the palm will not only increase the stability and security of Nadina's hold, allowing her to complete daily tasks such as doing her makeup more easily, but it will also reduce the need for complex finger coordination and dexterity in order to hold the object in place. Because the grip will already mould to the object, Nadina will only have to lightly squeeze the fingers of her left hand closed to create a stable hold, decreasing the amount of pressure or strength needed to hold objects. This will not only make tasks like doing makeup or brushing hair more comfortable for Nadina, but it will also allow her to do these tasks for longer periods of time without over-straining her hand or exhausting her strength.



Figure 5. Demonstration of holding an object with the device, showing that only a loose grip is required to hold an object securely

Product Identification

Appearance: The prototype is a black, fingerless glove with a slot for the patient's little finger and thumb. The grey pad attached to the black glove is filled with bendable wires to aid the patient in gripping objects. There is also a non-slip rubber pad on the grey fabric to further assist with grip. The plastic attachment strip at the base of the glove helps the patient take off and put on the glove one-handedly with ease.

Key Features:

- Glove: A black, fingerless, nylon glove acts as the base of the prototype.
- Grip pad: A grey pad is attached to the palm area of the glove. The pad is filled with malleable wires that can be adjusted to allow the patient to grip objects more easily. Due to the wires, there are raised areas of the pad for the client to put objects in between. Non-slip rubber pads were placed in between the raised areas to assist with grip.
- Plastic strap: A rectangular plastic strip is attached to the bottom of the glove. This is used in conjunction with command hooks (placed on a flat surface) to aid the patient in putting on the glove and taking it off.
- Finger slots prevent slipping of glove (slots for the patient's thumb and little finger).

Function: This glove is meant to help the client, Nadina, with picking up small to medium-sized objects such as makeup products, toothbrushes, and hairbrushes. The glove assists Nadina with grip strength by holding objects in between the raised areas on the grey grip pad.

Usage

Instructions

1. Place two command hooks, about an inch apart, on a flat surface.
2. Hook the horizontal plastic strip into the command hooks so that it is secure.
3. Slide your left hand into the glove, making sure that your thumb and little finger are in their designated slots.
4. Pick up objects by positioning the glove so that objects fit in between the raised surfaces of the grey grip pad.
5. To take off the glove, hook the horizontal plastic strap into the command hooks again, and slide your hand out.

Ergonomics: The raised surfaces of the grey gripping pad were placed in a way that objects can be grabbed comfortably, without the same amount of grip strength. The stretchy, nylon material that the glove is made of makes the glove comfortable for long periods of time and makes the prototype machine washable.

Reliability: The glove can be used for long periods of time. However, the wires that are sewn into the grey gripping pad will likely eventually lose their firmness after several months of regular use. Therefore, in future iterations, the grey gripping pad would be replaceable. Otherwise, the absence of technological components in this prototype leaves little room for error.

Service Environment: This device would be used in a bathroom setting as it was made to help Nadina with her daily tasks such as doing makeup, brushing her teeth, and doing her hair. Therefore, it is safe to assume that this

glove would be getting wet and exposed to different styling products. The glove is nylon, and the gripping pad is made of fabric, so the glove is safe to get wet and can be machine-washed as needed.

Standards and Safety

The device meets all safety standards that are required of it (considering that there are no technological components, there are not many). However, due to the relatively sharp edges of the plastic strap and command hooks, there is a possibility that Nadina could scratch her hand or arm when putting on the glove. In the future, this would be addressed by making that plastic strap out of firm rubber or another dull material.

Appendices

Appendix A: Project Schedule

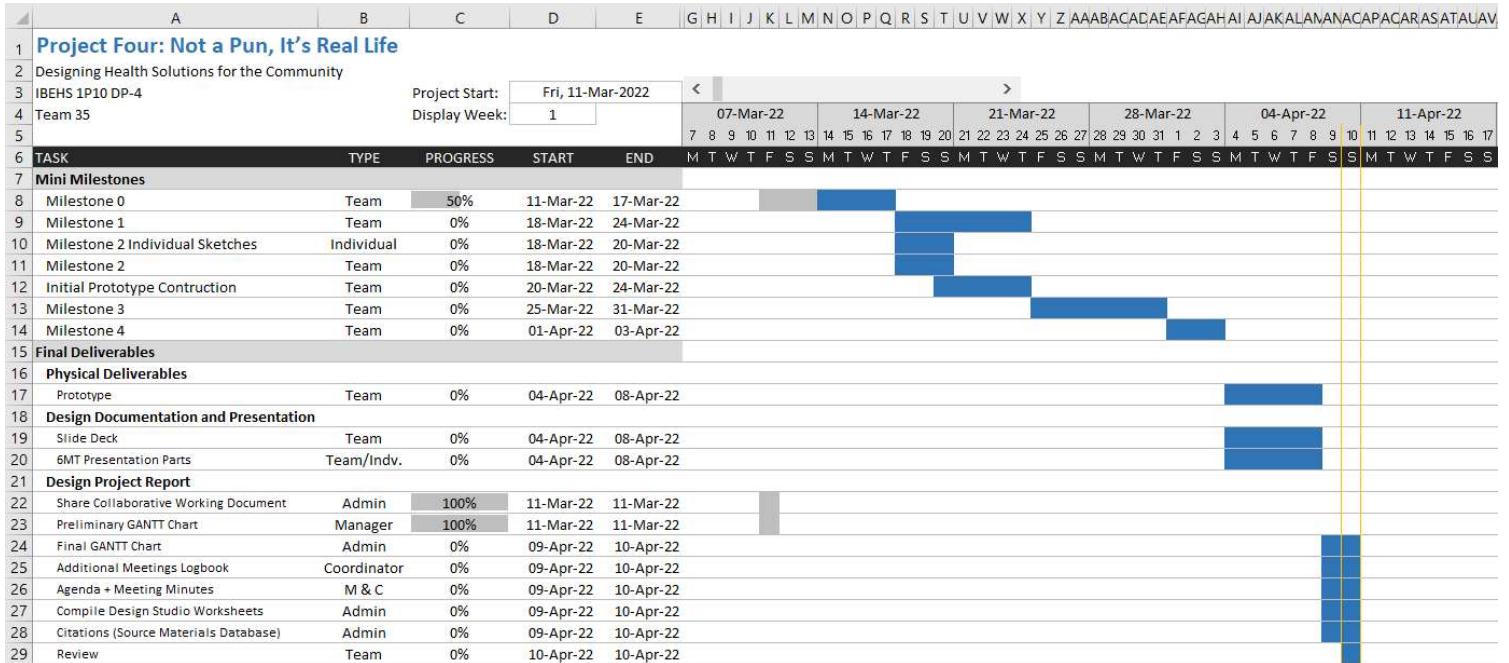


Figure 1. Preliminary Gantt Chart

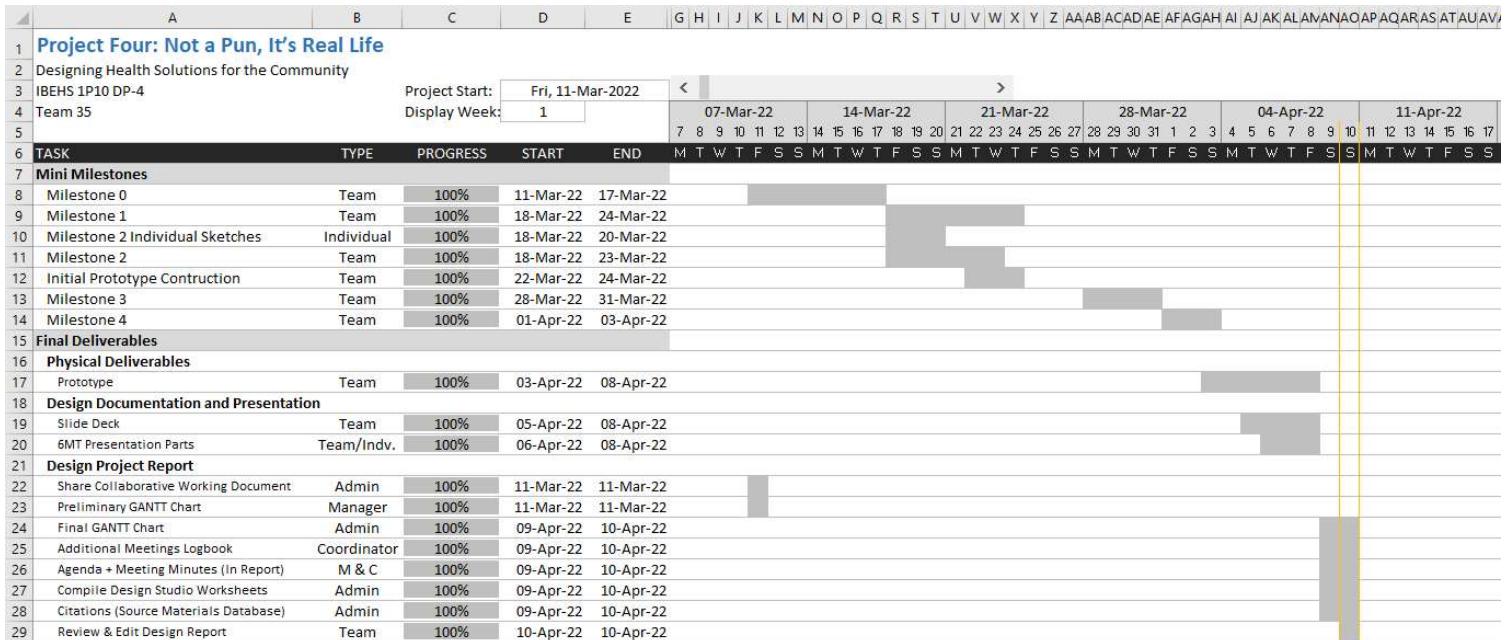


Figure 2. Final Gantt Chart

Additional Meetings Logbook**1. March 7th – 5:30 pm to 6:00 pm (MS Teams)**

- Finalized Milestone 1 (need statement and customer requirements)
- Review Milestone 2 requirements before next week's DS
- Members Present: Mattia, Spencer, Emeline, Elias

2. March 17th – 1:00 pm to 1:30 pm (MS Teams)

- Completed concept evaluation table
- Made initial prototype using materials from home (tape, paper, and an old winter glove)
- Members Present: Mattia, Spencer, Emeline, Elias

3. April 4th – 7:00 pm to 7:45 pm (MS Teams)

- Began planning and delegating tasks for the medium fidelity prototype
- Members Present: Mattia, Spencer, Emeline, Elias

4. April 6th – 6:30 pm to 7:00 pm (MS Teams)

- Continued working on medium fidelity prototype
- Planned/divided PowerPoint roles
- Members Present: Emeline and Elias

5. April 7th – 2:30 pm to 6:30 pm (Design Studio)

- Finished prototype for presentation (last-minute sewing and assembly)
- Finalized slides for tomorrow's presentation
- Continued to work on design report
- Divided tasks for final prototype video
- Filmed for the presentation demo video
- Members Present: Mattia, Spencer, Emeline, Elias

Figure 3. Logbook of Additional Meetings

Appendix B: Scheduled Weekly Meetings

IBEHS 1P10

MEETING WITH TEAM 35 – FRIDAY, MAR. 11th, 2022

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	Spencer McLean	mcleas13	Yes
Administrator	Emeline Bespalov	bespaloe	Yes
Coordinator	Mattia Solenka	solenkam	Yes
Subject Matter Expert	Eli Taylor	tayloe26	Yes
Guest			

AGENDA ITEMS

1. Any additions to milestone 1 necessary, any aspects we have yet to think of?
2. Looking back: our need statement, should we get more specific with what "daily tasks" we want to help Nadina accomplish
3. Looking forward: what method of idea generation is going to work best as a group?

MEETING MINUTES

1. . Generated prototype ideas through group brainstorming
 - a. Everyone contributed 2-3 of their own ideas
2. Sketches were divided across the group
 - a. Everybody to complete the sketch for the ideas that they contributed during the brainstorming session
3. Meeting scheduled for next week to complete concept evaluation and complete prototype for next week's Design Studio
 - a. Monday or Tuesday?
4. Prototype idea to be determined from results of concept evaluation

POST-MEETING ACTION ITEMS

1. *Finish the sketches for the prototype ideas that you contributed [All]*
2. *Schedule meeting for concept evaluation and prototype development before next week's Design Studio [Mattia]*

IBEHS 1P10

MEETING WITH TEAM 35 – FRIDAY, MAR. 18th, 2022

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	Spencer McLean	mcleas13	Yes
Administrator	Emeline Bespalov	bespaloe	Yes
Coordinator	Mattia Solenka	solenkam	Yes
Subject Matter Expert	Eli Taylor	tayloe26	Yes
Guest	Abby McEwan	mcewa22	Yes

AGENDA ITEMS

1. Is it alright for us to have a completely different prototype than our final design?
2. Sensors? Pi integration? CAD-ing? Or is this project a by-any-means-necessary project?
3. Is this novel enough? (struggling to come to something that feels important)
4. How did physics go for everyone?
 - a. Remember that it was only worth 10%
 - b. Remember that physics does not matter nothing is real
5. Looking back:
6. Looking forward:

Meeting Minutes

1. Design Review today! Advice from reviewers:
 - a. Glove may be too difficult for Nadina to put on and take off as is
 - b. Entire glove may be unnecessary as it further restricts Nadina's movements
 - c. Possibility of adding magnetic strips to glove so that objects picked up are more secure?
2. Discussed feedback as a team
 - a. How can we incorporate into future iterations?
3. Begin next prototype iteration
 - a. Meeting scheduled to continue working on next prototype

POST-MEETING ACTION ITEMS

1. *Meeting to finish prototype on Thursday [Mattia]*

IBEHS 1P10

MEETING WITH TEAM 35 – FRIDAY, MAR. 25th, 2022

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	Spencer McLean	mcleas13	Yes
Administrator	Emeline Bespalov	bespaloe	Yes
Coordinator	Mattia Solenka	solenkam	Yes
Subject Matter Expert	Eli Taylor	tayloe26	Yes
Guest	Abby McEwan	mcewaa2	Yes

AGENDA ITEMS

1. In our design review we got advice to keep this device simple, within a specific niche – would we benefit from just focusing on one object-holding method in the glove or does having multiple straps make sense?
2. Discussion of how this glove is going to be put on should happen, Nadina can only use one hand, how can we tailor this design to meet that need that we missed?
3. How did linear algebra go for you guys?
 - a. Let's take a look at the course balance relating to this project – are we doing enough/doing too little, how can we make this project better fit with our busy schedules right now (1ZB I'm looking at you!)
4. Looking back: We have a prototype, what do we think of the current state of it?
5. Looking forward: Do we want to build a second prototype? What methods should we use to help her be able to hold items?

Meeting Minutes

1. Second Design Review today! Advice from reviewers:
 - a. Straps may not secure objects. Another alternative for grip?
 - b. How will Nadina put on the glove? Still may be too difficult given her abilities.
 - c. Material choice?
2. Work on further developing prototype

POST-MEETING ACTION ITEMS

1. Build new 'ion channel' type holding mechanism [Emeline]
2. Work on ideating a method that allows Nadina to put on the glove with one hand [Spencer, Elias]

IBEHS 1P10

MEETING WITH TEAM 35 - FRIDAY, APR. 1, 2022

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	Spencer McLean	mcleas13	No (excused absence)
Administrator	Emeline Bespalov	bespaloe	Yes
Coordinator	Mattia Solenka	solenkam	No (excused absence)
Subject Matter Expert	Elias Taylor	tayloe26	Yes
Guest			

AGENDA ITEMS

1. Design Report Roles
2. Design Refinements
3. Materials Selection

MEETING MINUTES

1. Delegating design report sections
 - a. Eli – Background & Research Summary, Emeline – Description of Proposed Solution, Spencer/Mattia - [any 2 of the remaining sections each], everyone – Executive Summary
2. Design Refinements
 - a. Include a Velcro strap locking mechanism for an open-back glove
 - b. Make the glove easier to slide on
 - c. Include a finger/thumb strap that can be used as an anchor when sliding the glove on
 - d. Make straps adjustable and replaceable using a Velcro pad in the palm of the glove
3. Materials
 - a. Velcro + elastic to make strap (elastic straps we can get from design studio)
 - b. Include a device to help unlock the strap (little Velcro patch that can be mounted on a surface and used to help unwrap the glove)
 - c. Bendable wires (worst case scenario we use pipe cleaners)
 - d. Fabric for glove (probably something a little sturdier than the original glove material, so it's easier to wrap)

POST-MEETING ACTION ITEMS

1. *Finish delegating the design report sections (Mattia and Spencer)*
2. *Purchase any required materials this weekend (everyone)*
3. *Build medium fidelity prototype (everyone)*

IBEHS 1P10

MEETING WITH TEAM 35 – FRIDAY, APR. 8th, 2022

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	Spencer McLean	mcleas13	Yes
Administrator	Emeline Bespalov	bespaloe	Yes
Coordinator	Mattia Solenka	solenkam	Yes
Subject Matter Expert	Eli Taylor	tayloe26	Yes
Guest	Abby McEwan	mcewaa2	Yes

AGENDA ITEMS

1. How much preparation do we need for the presentation?
2. How are we feeling about the whole thing?
3. Mostly today it seems that we want to focus on practicing our presentation and nailing down our parts – but there are other deliverables. What do we need to prepare for the video, design report, etc.
4. Looking back: Prototype looks great! Awesome job guys!
5. Looking forward: I think we are going to kill it with this presentation. Good luck of course to us!

Meeting Minutes

1. Everyone to practice their scripts for their individual presentation sections
 - a. Everyone gets about 1:30 minutes to speak (6-minute presentation limit)
2. Slides finalized
3. Prototype videos filmed to incorporate into slides
4. Time given to work on design report

POST-MEETING ACTION ITEMS

1. *Have a great presentation! [All]*

Appendix C: Design Studio Worksheets

Milestone 0

MILESTONE 0 – COVER PAGE

Team Number: 35

Please list full names and MacID's of all present Team Members

Full Name:	MacID:
Elias Taylor	tayloroe26
Emeline Bespalov	bespalov
Mattia Solenka	solenka
Spencer McLean	mcleas13

Any student that is *not* present for Design Studio will not be given credit for completion of the worksheet and may be subject to a 10% deduction to their DP-4 grade.

Please attach your Team Portrait in the dialog box below



MILESTONE 0 – TEAM CHARTER

Team Number: 35

Incoming Personnel Administrative Portfolio:

Prior to identifying Leads, identify each team members incoming experience with various Project Leads

	Team Member Name:	Project Leads
1.	Elias Taylor	<input checked="" type="checkbox"/> M <input checked="" type="checkbox"/> A <input checked="" type="checkbox"/> C <input type="checkbox"/> S
2.	Emeline Bespalov	<input checked="" type="checkbox"/> M <input checked="" type="checkbox"/> A <input checked="" type="checkbox"/> C <input type="checkbox"/> S
3.	Mattia Solenka	<input checked="" type="checkbox"/> M <input type="checkbox"/> A <input checked="" type="checkbox"/> C <input type="checkbox"/> S
4.	Spencer McLean	<input checked="" type="checkbox"/> M <input checked="" type="checkbox"/> A <input checked="" type="checkbox"/> C <input type="checkbox"/> S

To 'check' each box in the Project Leads column, you must have this document open in the Microsoft Word Desktop App (not the browser and not MS Teams)

Project Leads:

Identify team member details (Name and MACID) in the space below.

Role:	Team Member Name:	MacID:
Manager	Spencer McLean	mcleas13
Administrator	Emeline Bespalov	bespalov
Coordinator	Mattia Solenka	solenka
Subject Matter Expert	Elias Taylor	tayloroe26

Milestone 1

MILESTONE 1 – COVER PAGE

Team Number:

Please list full names and MacID's of all present Team Members

Full Name:	MacID:
Eli Taylor	tayloroe26
Spencer McLean	mcleas13
Emeline Bespalov	bespaloe
Matia Sporadic	sporadic

Any student that is *not* present for Design Studio will not be given credit for completion of the worksheet and may be subject to a 10% deduction to their DP-4 grade.

MILESTONE 1 (STAGE 1) – CLIENT VISIT QUESTIONS WORKSHEET

Team Number:

As a team, prepare a preliminary **list of questions** to ask your client. Enter questions in the space below.

Preliminary List of Questions:

NADINA

- What types of physical limitations does multiple sclerosis bring to your life?
 - Are there specific tasks/activities that you can't do independently?
- Are there any types of activities that exacerbate your symptoms?
- What are some mobility or dexterity limitations that are part of your everyday life?
- What home tasks or activities do you wish were easier to do?
 - Hair and makeup
- Are there any limitations that come with using a wheelchair that you wish were different?
- What kinds of activities do you enjoy doing at home? Are there any of these activities that you wish were easier to do?
- Are there other health complications associated with diagnosis?

KEVIN

- Can you talk a bit more about some of the coordination challenges you experience?
- Are there certain tasks around the house that are affected by this?
- What are some activities where your right-hand limitations bother/affect you the most?
- Are there certain tasks where it's especially a problem?
- What are some of your hobbies/activities you enjoy doing?
- Do you wish any of them were easier to do?
- How does your use of a walker/wheelchair affect your life/daily activities?
- Are there certain physical limitations that impact you mentally/emotionally more than others?

Document any questions that come up *during* the client visit in the space below.

Additional Questions:

NADINA

- What behavior did you have to change in early stages (when muscle changes were sporadic)?

MILESTONE 1 (STAGE 2) – DOCUMENTATION OF DISCUSSION

Team Number:

As a team, document your discussions with the client during their visit.

NADINA

- Started with inability to control muscles (bumped into the wall, couldn't wash hair)
 - Couldn't feel left-side for thirty days, and then hand for thirty days (not textbook symptoms)
- Can't grip her wheelchair properly because of muscle weakness
- Did combat fitness for exercise before diagnosis
 - Had to find new ways to exercise - weight training (PACE - Nadina recorded workout to demonstrate specific weaknesses), aquafit
- Started with crutches, then wheelchair
- Prefers devices that are tailored to her current abilities, opposed to devices things that change or try to "retrain" muscles
- There's mainly only drugs for the early stages of MS, not so much for the later stages
- Future mobility goals: rebuilding strength
- Attacks are random (attacks of exacerbation or MS attacks)
- Can make you introvert - Nadina is an extrovert
- Botox: needle is injected into specific parts of muscle, frees up body part and increases range of motion (shoulder, wrist)
- Exercises twice a week - fatigue is different every day
- Lack of exercise due to COVID made all actions harder - strength declined
- Right-handed before injury - muscle issues on right side
- Challenges coordinating left hand movement - makes tasks like using utensils difficult
- Issues related to spasticity - pain related to that

What behaviour did you have to change in early stages when muscle changes were sporadic?

- Friend had to do makeup and hair
- A lot of people get discouraged at this stage

What drives you to continue daily tasks instead of getting discouraged?

- Don't have pity parties - have moments of anger or pity but don't let them last too long and don't stress too much

Where do you face accessibility challenges?

- Buttons for automatic doors in stores are too far away from door
- Bar in wheelchair accessible washrooms are weirdly positioned
- Accessibility features are not made with disabled people in mind

Do you use / Would you like to use other devices besides a wheelchair?

- A lot of aids don't allow you to do anything (e.g. a brace is put on but then user has little control over actions)
- Prefer to prioritize activities and tools/devices that enhance the capabilities she currently has, rather than things that try to change her abilities
- Want accommodations and tools that challenge you a little bit, not wanting to develop a significant dependence on devices
- Annoyances with wheelchair, work out and then have to sit in chair for hours

What type of exercise do you do?

- Free weights (bicep curls)
- Need someone to push arm in
- Exercise limitations: can't work out hamstrings anymore and if exercise is too aggressive, muscles will freeze up
- Consistently working muscles helps make them less resistant
- Exercises at home: resistance bands, basic exercises

How did diagnosis affect your mental health/relationship with family and friends?

- Diagnosis caused a lot of anxiety, family and friends feel bad
- Affects sense of independence – getting ready, doing hair, needing people for everything

KEVIN

- Stroke – one side paralyzed
- Aphasia zoom meetings – uses iPad to help with aphasia
- Issue is not physical in regards to leg – neurological connection issue
- No issues operating digital devices
- No issues getting up stairs
- No issues with left side
- Used to play competitive volleyball
- Used to play golf
- Significant issues with balance
- Issues with lifting leg (e.g. over side of bath tub)
- Cognitive issues (e.g. math)
- Right knee doesn't bend (bends slightly)
- Currently has Xpresso Walker

What kinds of tasks have been impacted?

- Walking is an issue – laboured, needs walker around house
- Dexterity issues with hands
- Independent living

What kinds of things do you enjoy doing in your spare time?

- Playing chess
- Riding a bike

- Watching news
- Routine helps a lot

How has PACE helped?

- PACE twice a week
- Physiotherapist once a month
- "homework" type exercises aren't good – poor form without supervision and having a break is good
- Gives a sense of purpose – social aspect, friends, interaction

What types of physiotherapy do you do?

- Weights
- Balance therapist
- Bicep curls
- Overhead lifting
- Pushing to get out of seat

What aspect of life would you wish to have back?

- Walking

Are there any issues with using a walker / things you would like to see improved?

- Issues managing both walker and wheelchair
- Holding walker while using wheelchair
- Uses travel wheelchair (having to decide between bring / using wheelchair or walker)
- Walker is bulky – hard to transport via car, same with wheelchair

Would you prefer devices that perform the task for you or devices that help you do the task with the capabilities you have?

- Devices that support his capabilities and help him develop his abilities more
- Allow opportunities for him to do things and perform daily tasks

What are the limitations that make it necessary to use a walker?

- Helps with balance, issues with coordination
- Cane didn't help
- Walker supports physically when walking

What are some issues with accessibility that you experience in your community?

- Weights of doors
- Accessible doors for washrooms
- Wheelchair is not always available (sometimes available for part of the time but then it is taken away)
- Issues with reactions, awareness, and attitudes towards disabilities by service workers

What is the most challenging part of travelling?

- Planning trips and events in advance

- Airport accessibility
- Challenging with just one person to help

Any possible improvements in hospital experience?

- Physiotherapy
- Speech therapy
- Missing transition between hospital stay and living at home
- Looking for resources – aphasia group
- Focus less on strengthening leg – need to fix mental connection

MILESTONE 1 (STAGE 4) – CUSTOMER REQUIREMENTS

Team Number:

As a team, develop a list of customer requirements that detail what the proposed solution should do and achieve. For each requirement, categorize in parentheses as an objective, constraint or function. As a reminder, requirements **can be** more than one of the three.

List your customer requirements in this field. Bullet-point format is acceptable. Requirements can be written as either a brief sentence or 2-4 words, whichever is most appropriate. For each requirement, indicate (in parentheses) whether it is an objective, function, or constraint.

1. This solution should work long term as well as short term – meet changing needs (objective)
2. This solution should be user-friendly - able to be operated by Nadira alone (objective)
3. This solution must meet safety regulations and standards (constraint)
4. This solution must not impede Nadira's independence of motion (constraint)
5. This solution should be portable – at least within the house (objective)
6. This solution needs to support the function of her right arm and/or hand (function)
7. This solution needs to reduce the physical exertion required to perform daily tasks (function)

MILESTONE 1 (STAGE 3) – NEED STATEMENT

Team Number:

Write your Need Statement in the space below. Recall that your need statement should:

- Have a clearly defined problem (what is the need?)
- Indicate your client (who has the need?)
- Have a clearly defined outcome (what do you hope to solve and why is it important?)

NEED STATEMENT:	Design a device for Nadira that helps her accomplish daily tasks made difficult due to muscle weakness caused by multiple sclerosis, while maintaining a sense of independence.
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MILESTONE 1 (STAGE 5) – ENGINEERING SPECIFICATIONS

Team Number:

As a team, translate your customer requirements into a set of engineering specifications, spelling out in precise, measurable detail what the design solution is supposed to do.

List your engineering specifications in this field. Bullet-point format is acceptable. Ensure it is clear what engineering specification aligns with each customer requirement.

- (If powered by a battery) Needs to be able to last a full day of use [objective 5]
- Needs to allow her to perform daily tasks for longer periods of time (e.g. brushing hair, using utensils) [objective 2]
- Needs to be able to be carried by Nadira with her current strength [objective 5]
- Needs to allow her to carry more weight / use more force with her right arm and/or hand [objective 2]

Milestone 2

MILESTONE 2 – COVER PAGE

Team Number:

Please list full names and MacID's of all present Team Members

Full Name:	MacID:
Emeline Bespalov	bespaloe
Elias Taylor	tayloroe26
Spencer McLean	mcleas13
Matija Solenka	solenkaro

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MILESTONE 2 (STAGE 1) – IDEA GENERATION

Team Number:

- As a team, outline several potential concept solutions
 → Your ideas can be sketches or bullet-point descriptions
 → Be creative with the materials you choose and the modifications you propose
 → Be sure to clearly write your Team Number, Name and MacID
- Take a photo of your work
- Insert your photo as a Picture (Insert > Picture > This Device).
- Do not include more than one sketch per page**

Insert screenshot(s) of your idea generation below

DP-4: Milestone 2 Concept Generation

Friday, March 11, 2022 12:53 PM

Concept 1 : Elbow rests

↳ used to support Nadina while she's doing her hair, makeup, or brushing her teeth
 ↳ elbow rests support Nadina's arms so that her arms can be raised for longer periods of time



Concept 2 : toothbrush tool

↳ similar to toothbrush holders that go on walls
 ↳ hand-held device/glove that has hooks to hold a toothbrush
 ↳ reduces need for grip strength

Concept 3: Grip strength tool
 ↳ tool utilizes levers, allowing Nadina to grip objects in her hand, but with less force required
 ↳ hand-held device - fit to hold items like toothbrushes, makeup items, etc.

Concept 4: Elbow movement device
 ↳ allows Nadina to hold positions for longer periods of time by "locking" position into place
 * include concept sketch

Concept 5: wearable arm device
 ↳ worn on upper-arm and can be adjusted to move arm
 ↳ mechanism could be remote-controlled or controlled by a switch
 * concept sketch

Concept 6: Lower-arm brace
 ↳ allows Nadina to strap items onto hand so that she doesn't have to fully grip the items

Concept 7: Wall-mounted holding bracelet
 ↳ adjustable rod that is attached to wall that holds toothbrush/makeup products
 ↳ Nadina can adjust rod to go where she needs it to
 * concept sketch

Concept 8: hand-held holding device
 ↳ attaches to Nadina's hand and can rotate to relieve pressure off of Nadina's wrists
 ↳ holds toothbrushes, makeup, hairbrushes, etc.

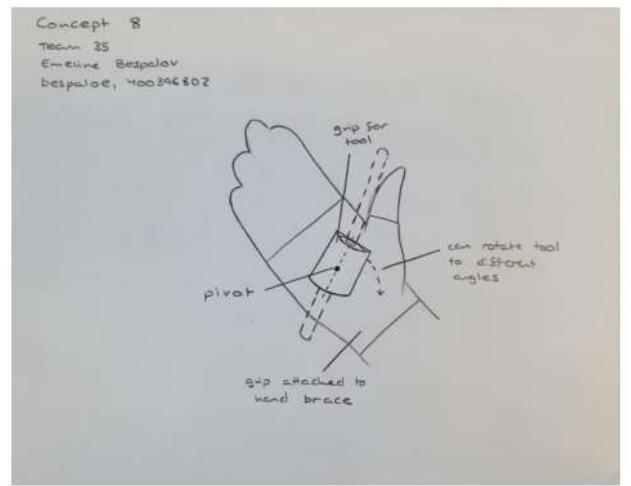
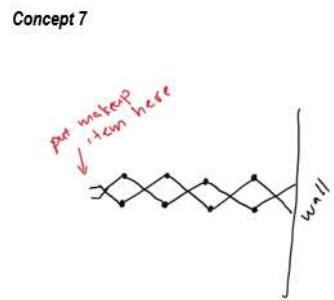
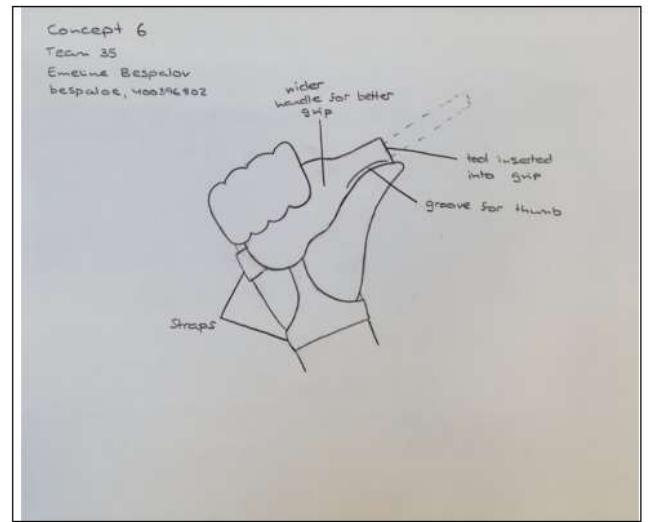
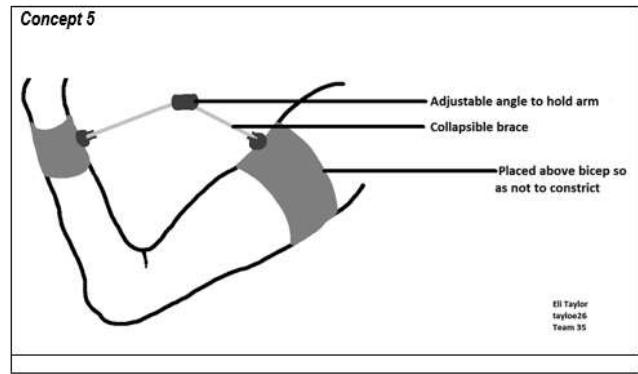
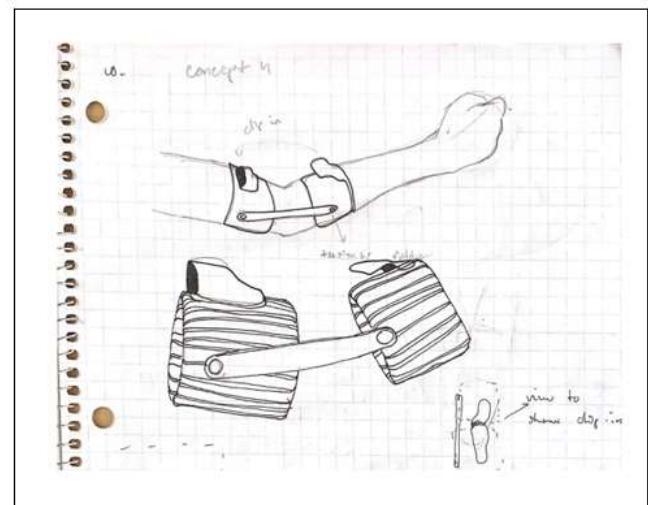
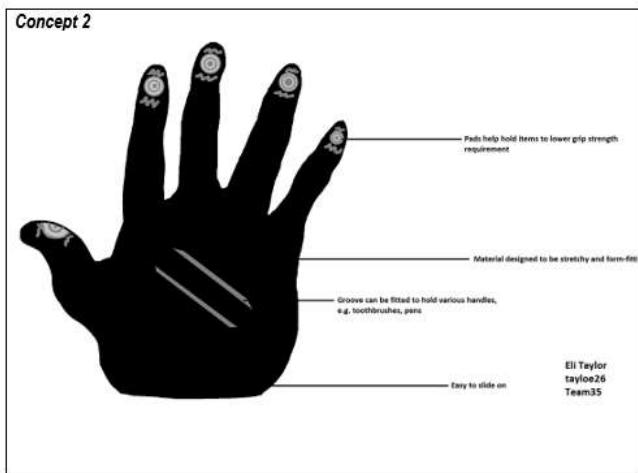
MILESTONE 2 (STAGE 2) – CONCEPT SKETCHES

Team Number:

- Complete your sketch on a separate sheet of paper or a whiteboard
 → Be sure to clearly write your Team Number, Name and MacID
- Take a photo of your work
- Insert your photo as a Picture (Insert > Picture > This Device).
- Do not include more than one sketch per page**

Concept 1





MILESTONE 2 (STAGE 3) – PUGH MATRIX

Team Number: 35

1. As a team, evaluate your concept solutions in the table below

- List your Criteria in the first column
 - You should include a minimum of 5 criteria
- Fill out the table below, comparing your designs against a baseline concept (the decision of a baseline concept is arbitrary and entirely up to your team to decide)
 - Replace "Concept 1", "Concept 2", etc. with more descriptive labels (e.g., a distinguishing feature or the name of student author)
 - Indicate a "+" if a concept is better than the baseline, a "-" if a concept is worse, or a "S" if a concept is the same

	<i>Elbow Rest</i>	<i>Grip Slot Wearable</i>	<i>Lever Grip Device</i>	<i>Elbow Movement Device</i>	<i>Wearable Arm Device</i>	<i>Lower Arm & Hand Brace</i>	<i>Wall-Mounted Holding Bracket</i>	<i>Movable Joints Device</i>
<i>Not obtrusive/bulky</i>	-1	0	-1	-1	-1	0	0	-1
<i>Ease of application</i>	+1	0	0	-1	-1	-1	0	-1
<i>Reduces physical exertion</i>	+1	0	+1	+1	+1	0	+1	0
<i>Portable/easy to carry</i>	-1	0	0	0	0	+1	-1	-1
<i>Works long-term</i>	0	0	0	0	+1	0	0	0
<i>Does not inhibit current range of motion</i>	-1	0	-1	-1	-1	0	+1	+1
<i>Compatible with different tools</i>	+1	0	+1	+1	+1	+1	+1	+1
Total +	3	0	2	2	3	2	3	2
Total -	3	0	2	3	3	1	1	3
Total Score	0	0	0	-1	0	+1	+2	-1

2. Indicate the concept(s) you have selected to pursue for further development and testing, include **justification**

The general designs that we would like to pursue and further investigate are a hand brace gripping device and an arm brace bending device. These would both be wearable devices, and would both help Nadina complete tasks that require her to lift her hands up to her face, and grip any tools required for tasks like combing her hair or doing her makeup. The device would consist of straps that secure a grip slot part to the palm of the hand. Tools can be inserted into the grip slot part to securely hold them in place. We would like to further test the hand brace gripping device because it would help reduce the grip strength and coordination needed to hold something like a comb, and it would ensure the tool is securely held while Nadina is completing the task, allowing her to have more precision with something like a makeup tool. The hand brace design of the device would also ensure that it is portable, not bulky, and easily taken on and off.

Regarding the arm brace bending device, this would help Nadina with the issue of not being able to lift her right arm very high, or bend/straighten her arm at the elbow on her own. This device would allow her to secure her arm into a bent position using arm bands on the lower and upper arm, with parts that would be able to be hooked together to keep her elbow in the bent position. This design in combination with some sort of hand device like the one described above could help Nadina complete tasks that require her to have her hands lifted up to her face for an extended period of time, such as makeup.

* It's perfectly acceptable to consider more than one design at this point.

3. Briefly describe any **design refinements** that your team will consider for the selected concept. Design refinements include any changes or modifications that deviate from the initial design. These changes or modifications may be based on *other* designs that were proposed but not selected, or they may be derived from discussions during your team's concept evaluation.

Regarding the hand brace gripping device, we plan to refine the part of the device that encases/holds the tool. A slot grip can accommodate different sizes and shapes of tools, but it may be less secure than a grip with some sort of hole that the tool is inserted into. We also have to consider whether we want the grip to be adjustable for size and angle, or if we simply want a one-size-fits-all stationary grip (i.e. something made out of a more flexible material that is directly attached to the brace, rather than being attached on a pin for rotation). We also may want to modify the brace/glove nature of the design, as we want to preserve as much mobility in the hand as possible, and we don't want the brace to feel invasive. We could perhaps change the brace and straps to soft, elastic straps that can be easily slid on and off without needing to deal with Velcro or other fasteners. In addition, to make it easier to position the tools in the grip part of the hand device we could add magnets to the inside of the grip and provide adhesive magnet strips for Nadina to stick to the tools she uses on a regular basis.

If we choose to pursue the arm brace bending device, we plan to refine the arm brace component to be more streamlined and easier to take on and off with one hand. Rather than a cuff design, we could change this to a thick strap that can be wrapped around the arm and secured with a button or clasp, so it could be easily put on over clothing. Another refinement could be incorporating multiple hooking components along the arm bands, allowing for the arm to be adjusted to different angles of elbow bending to suit the needs of different tasks.

Milestone 3**MILESTONE 3 – COVER PAGE**Team Number: Please list full names and MacID's of all *present* Team Members

Full Name:	MacID:
Mattia Solenka	solekam
Emeline Bespalov	bespaloe
Elias Taylor	taylor26
Spencer McLean	mcleas13

Any student that is *not* present for Design Studio will not be given credit for completion of the worksheet and may be subject to a 10% deduction to their DP-4 grade.**MILESTONE 3 (STAGE 2) – DESIGN REVIEW #1 FEEDBACK**Team Number:

Use the space below to document feedback for your design.

Questions:

- Do you think we should take a more minimalist approach with the glove (i.e., use straps or a brace design instead of a full glove)?
- Do you have any suggestions to improve the mobility or versatility of the grip part of the glove (i.e., to make it able to hold different types of tools or at different angles)?
- Are there any concerns you have about the stability/security of the grip with this current design?
 - Do you think there is anything we could add to the glove to make the grip more stable?
- What do you think about adding some sort of mechanical part to the back of the glove to help curl and uncurl her hand? (right hand?)

Notes:

- Make grip slot bigger – learn biggest object she would want to place inside and use that as a reference for how wide the grip space should be
- Add magnetic strips for more security (magnetic strips can be stuck on the tools she uses frequently, and on the grip slot)
- Sides of the grip slot would just be for added security (i.e., magnets could be main method of adhesion, and then sides of grip part support the tool)
- Grip slot should be located closer to edges of glove to accommodate smaller tools (e.g., shorter objects such as lip balm)
- Elastic strap to wrap around tool vs magnet for adhesion?
- Coarser material for grip part of brace – sturdier and easier to find for prototyping
- Process: making sure items stay in place and then improving precision and streamlining device
- Mechanical integration: Keep it for next steps rather than incorporating into actual prototype
- Could have a thumb-only glove to make sure the device is always put on in the right position – grooves or indentations on the grip part of the glove could help guide where Nadina's fingers should go

Use the space below to propose design refinements based on the feedback.

- Add features to address precision issues with the left hand.
 - i.e., are there ways we could stabilize Nadina's left hand while doing tasks?
- Add magnetic strips on the grip slot that would allow for easy attachment to tools - the tools that Nadina frequently uses would have corresponding adhesive magnetic strips stuck to them.
- Make the glove less bulky to ensure control level is not degraded - this could involve changing the glove into a hand strap with a grip slot mounted on it (e.g., elastic straps that slide onto the hand, securing the grip slot to the palm).
 - Also incorporate a thumb hole into the strap-glove to help with putting the device on, and to help make sure the device is correctly positioned every time Nadina puts it on.
- Make the grip slot wider to accommodate a greater variety of tools (but also make the physical sides of the grip smaller so it's less bulky in the hand).
 - The sides of the grip slot could be moved further towards the edge of the hand as well, to make it easier to hold and use smaller/shorter objects.
- Use a coarse but semi-flexible material for the grip slot – this would allow it to have a bit of give when holding tools in place, while also being sturdy enough to secure them tightly in place.
- Investigate whether putting finger indentations or grooves on the grip slot would be feasible (the sides of the grip slot may end up being too small for indentations) – this could potentially help with normalizing the grip position of the left hand.

Milestone 4**MILESTONE 4 – COVER PAGE**Team Number: Please list full names and MacID's of all *present* Team Members

Full Name:	MacID:
Emeline Bespalov	bespaloe
Eli Taylor	taylor26
Mattia Solenka	solenka
Spencer McLean	mcleas13

Any student that is *not* present for Design Studio will not be given credit for completion of the worksheet and may be subject to a 10% deduction to their DP-4 grade.

MILESTONE 3 (STAGE 2) – DESIGN REVIEW #2 FEEDBACKTeam Number:

Use the space below to document feedback for your design.

Design Review Questions:

- Do you think we should be incorporating multiple adhesive methods, or should we just focus on one? E.g., friction fit, Velcro, and magnets?
- Do you have any suggestions regarding the materials we should use?
- How do we know if our product is truly high fidelity?
- Do you have any suggestions for how we could incorporate an adjustable component into our design? Do you think this is important to include?

Design Review Notes:

- Adjustable aspect: We could use Velcro; industrial strength Velcro
 - Elastic fabric straps are also good, but they do lose their strength over time and may eventually become too loose
 - Investigate a way to make the elastic straps replaceable
 - Maybe look into a different way of putting the device on (rather than having to fit your hand in the openings and pull it on)
 - Hook and loop mechanism could work, but it might be hard for her to operate
 - An elastic Velcro combination could be good, since the device would still have that adjustable aspect but with easier application (e.g., an elasticized glove that you can wrap around your hand and secure with Velcro)
- Magnets: may not be ideal, because if they're strong then they're hard to separate (especially if she must use her right hand to do it), and if they're weak they don't really add much
- VELCRO is a very good option – should find a way to incorporate it into the design
- We need to consider that she will have to use her right hand to put on the device, since the device is for her left hand
- Long term implications of the bendable wires: they can weaken and deform over time, meaning they may not hold their shape further in the future
- Need to consider specifically what objects the device is going to be used for – heavy vs light, big vs small
 - Determine how strong/wide the straps need to be, what material they need to be made of, etc.
- Maybe CAD fixed components that specifically fit certain objects (e.g., maybe a frame or a couple anchoring pieces to help keep the objects in place?)
- Consider a wrap around glove vs a pull-on glove – a wrap around glove or strap may be easier to put on, especially if the closure is not complicated to use (e.g., Velcro, snap buttons)

Use the space below to propose design refinements based on the feedback.

- We plan to modify the mechanism for how the glove is put on: we will pursue a wrap-around glove/strap style that uses Velcro or some sort of pressure closure (e.g., snap buttons) to secure it in place.
 - This would allow Nadina to easily put the device on, even with limited use of her right hand
 - We could design a wrap around glove so that she can hold a corner of the wrap around piece in place by folding her fingers down, and then rotating her wrist and pressing her wrist palm-down on a surface to secure the velcro/closure
- We plan to make the straps for securing objects adjustable, so that they can fit a wider variety of items
 - This could be done using Velcro straps across the palm
- We plan to explore ways we could make the elastic components of our device replaceable
 - This could maybe be achieved by securing the elastic straps to the glove with Velcro (possibly a stronger Velcro than what would be used on the straps themselves, since Nadina would not have to detach them on a regular basis)
- We plan to expand the straps on the palm so that there is more elastic coverage, helping make the hold of the glove on any object more secure
 - This could involve using more straps, or making the straps wider so they cover the whole length of the palm
- We will continue to evaluate the options of either pursuing a mouldable holding mechanism (e.g., bendable wires) or one that simply holds the objects tightly in place (e.g., elastic straps/pockets or Velcro)

Appendix D: Comprehensive List of Sources

- [1] “Multiple sclerosis,” *Mayo Clinic*, 07-Jan-2022. [Online]. Available: <https://www.mayoclinic.org/diseases-conditions/multiple-sclerosis/symptoms-causes/syc-20350269>. [Accessed: 10-Apr-2022].
- [2] “Updated atlas of MS shows over 2.8 million people worldwide have multiple sclerosis -- with nearly 1,” *National Multiple Sclerosis Society*, 11-Sep-2020. [Online]. Available: <https://www.nationalmssociety.org/About-the-Society/News/Updated-Atlas-of-MS-Shows-Over-2-8-million-People#:~:text=There%20are%20now%202.8%20million,living%20in%20the%20United%20States>. [Accessed: 10-Apr-2022].
- [3] “Assistive technologies options for people living with MS,” *MultipleSclerosis.net*. [Online]. Available: <https://multiplesclerosis.net/treatment/devices-software-other-tools>. [Accessed: 10-Apr-2022].
- [4] “Adaptive eating utensils: Eat independently again,” *Rehabmart.com*. [Online]. Available: <https://www.rehabmart.com/post/help-elderly-or-disabled-loved-ones-eat-independently-with-adaptive-eating-utensils>. [Accessed: 10-Apr-2022].
- [5] “Work gear,” *Work Gearz*. [Online]. Available: <https://workgearz.com/best-fabric-for-gloves/>. [Accessed: 10-Apr-2022].

Appendix E: Additional Documentation

Figure 1. An early planning document with images of the glove used to construct the prototype, along with some notes about the construction of the glove/indication of seams



Figure 2. A close-up of the strap mechanism used in our early prototype, where a pipe cleaner is sewn along the back of an elastic strap to give it more structure and malleability



Figure 2,3. Early shaping and modelling of the palm grip