

# **GNG2101 Final Report**

## **HAND GRIP**

Submitted by

Team B2A

Arjuunan Arulnamby, 300043459

Filip Bosnjak, 300021791

Hridyansh Sharma, 8701880

Adriana Marcela Vargas Roa, 300097975

December 21<sup>th</sup>, 2018

University of Ottawa

## **Abstract**

In this report, the different stages of the product design process are observed, based on the methodology suggested in the Introduction to Product Development and Entrepreneurship for Engineers and Computer Scientist course. The objective of this project was to solve a problem related to the design of a product that could improve the quality of life of a client with Thoracic syndrome. This syndrome caused severe muscle atrophy in the client's hands and fingers, which affected her fine motor skills and did not allow her to perform daily tasks. From meetings with the client it was possible to identify her needs, which allowed us to establish a problem statement. It was necessary to develop a glove-like support system to offer our client added strength along her Ulnar and Radial collateral ligaments, so she could have enough grip between thumb and other fingers. The design criteria for the product was to provide usability, comfort and improvement of fine natural motion of fingers. After an ideation of different solutions, brainstorming and sketching, the first prototype was built, which provided a display of the first concept and was useful to get the client's feedback. Iteratively, 3 prototypes were built using engineering tools and personal skills, such as CAD software and 3D printing, arduino coding and creativity. Finally, the last prototype was presented as a combination of a mechanical wires pulley system and an electronic device that gave movement to the other.

## **Table of Contents**

---

<b>Introduction</b>	<b>5</b>
<b>Engineering Design Process</b>	<b>6</b>
<b>Need Identification and Product Specification Process</b>	<b>6</b>
<b>Conceptual Designs</b>	<b>7</b>
<b>Project Planning and Feasibility Study</b>	<b>8</b>
<b>Analysis:</b>	<b>8</b>
<b>Prototyping, Testing and Customer Validation.</b>	<b>9</b>
<b>Final Solution</b>	<b>9</b>
<b>Business model</b>	<b>10</b>
<b>Economic Analysis</b>	<b>11</b>
<b>Conclusions and Recommendations for Future Work</b>	<b>12</b>
<b>Bibliography</b>	<b>13</b>

## List of Acronyms

---

Acronym	Definition
IPDECS	Introduction to Product Development and Entrepreneurship for Engineerings and Computer Scientist course
IEDP	Iterative Engineering Design Process
TS	Thoracic Syndrome
ALS	Amyotrophic Lateral Sclerosis

## **1 Introduction**

The problem to solve was to create a product that could be used by people with weakness or muscular atrophy in fingers for improving their handicraft. In this case, the problem was focused on limitations given by Thoracic syndrome. This is a relevant problem to solve as the quality of life of people with this condition is highly affected by this lack of strength, which doesn't allow them to perform properly their daily activities. It can be considered a physical limitation as they have poor dexterity in their hands.

Besides that, it is known that Thoracic syndrome has a lot of causes (<https://www.ccohs.ca/Oshanswers/diseases/thoracic.html>), such as trauma, anatomical defects and pressure on joints. Other conditions such as ALS may cause weakness and loss of limb movement. Muscular atrophy and loss of fine motor control along the thumbs' ulnar collateral ligament is not a just an issue people with thoracic outlet syndrome face. This is a symptom someone who has suffered a stroke or any kind of traumatic nerve damage could be dealing with. For this reason our product has huge potential market in the physiotherapy and rehabilitation field.

The goal in this project was to develop a glove-like support system to offer our client added strength and relief from the muscular degradation caused by Thoracic Outlet Syndrome while preserving her hand's natural range of motion. For this, the product was made to be a low cost, easy to use and versatile option. The fundamental requirements for our solution was for the device to be relatively minimal as not to interfere with daily life, have a portable battery pack, and most importantly to be able to artificially maneuver the thumb in a similar manner to the ulnar thumb pinch (the most common thumb movement).

## 2 Engineering Design Process

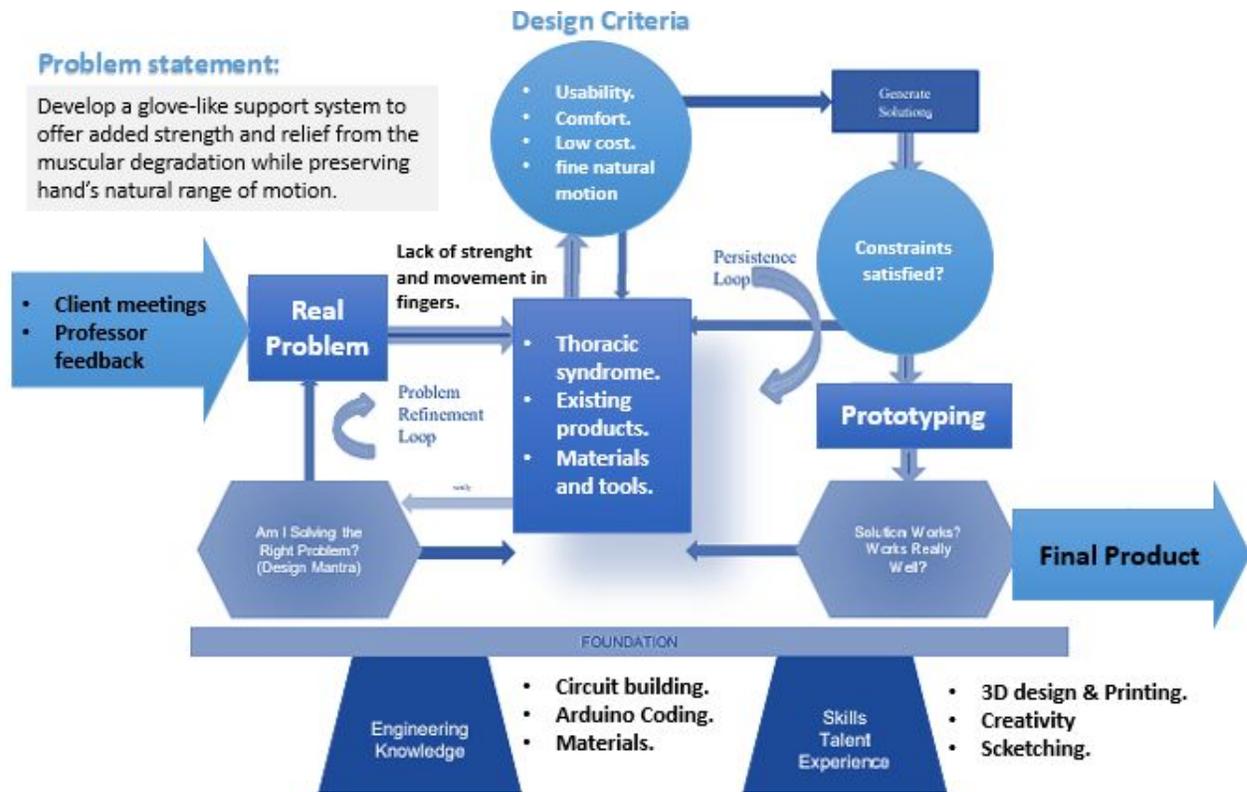


Figure 1. IEDP

## 3 Need Identification and Product Specification Process

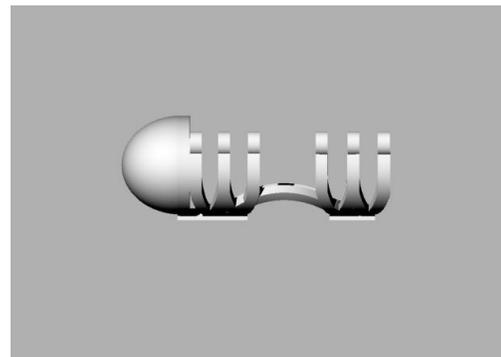
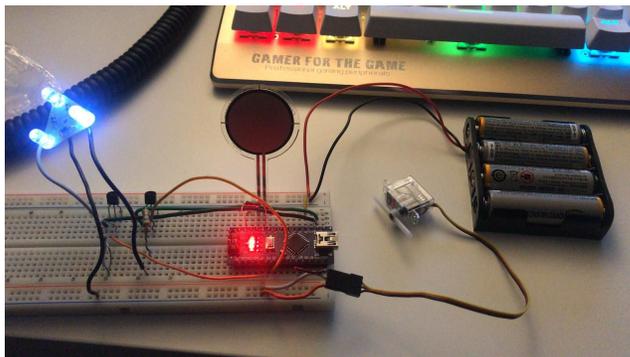
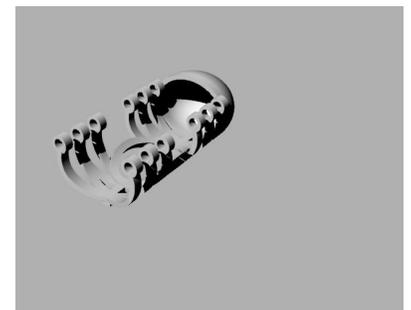
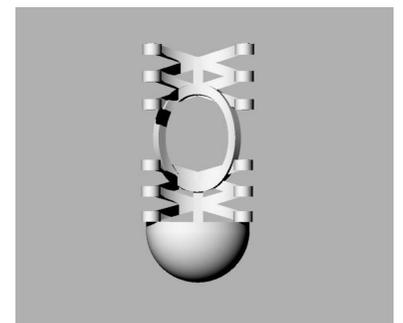
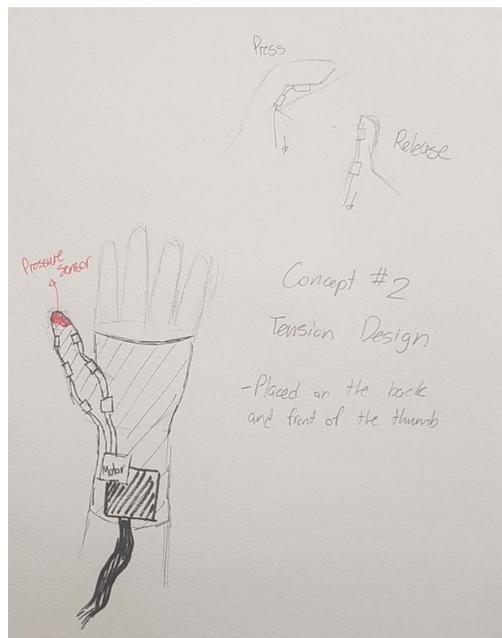
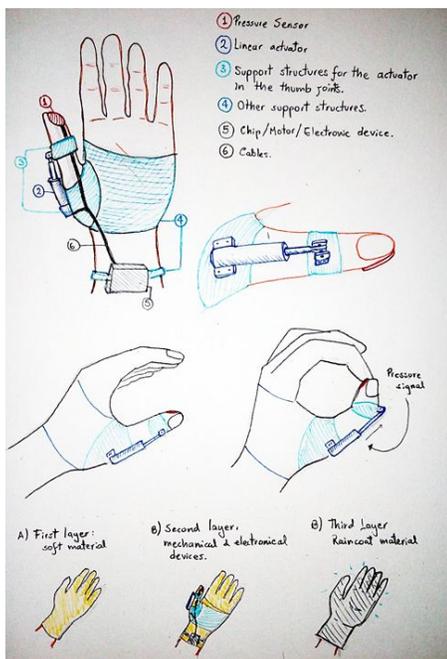
- The client realized approx. 5 years ago that she was losing function in her thumbs
- Both hands are affected by the syndrome, however, the right thumb is the main issue
- Had full range of motion in the hand
- Thumb would twitch out of the client's control when she was using it
- The muscle along the radial collateral ligament (abductor & flexor pollicis muscles) had deteriorated/ atrophied
- Thumb could not support more than or the weight of a ceramic plate
- The client used a clasping motion to make up for lack of strength in the thumb
- Request for the device be discrete and not overly invasive or heavy
- Ability to generate forward and torsional force along the Ulnar Collateral ligament
- A lightweight device that can be worn comfortably for extended periods of time

- Retain the fine natural motion of the hand to allow for the client to maneuver her thumb and fingers with a high degree of precision.

#### 4 Conceptual Designs

Our design criteria was based around these key factors:

- Ability to generate forward and torsional force along the Ulnar Collateral ligament.
- A lightweight device that can be worn comfortably for extended periods of time.
- Retain the fine natural motion of the hand to allow for the client to maneuver her thumb and fingers with a high degree of precision.



## 5 Project Planning and Feasibility Study

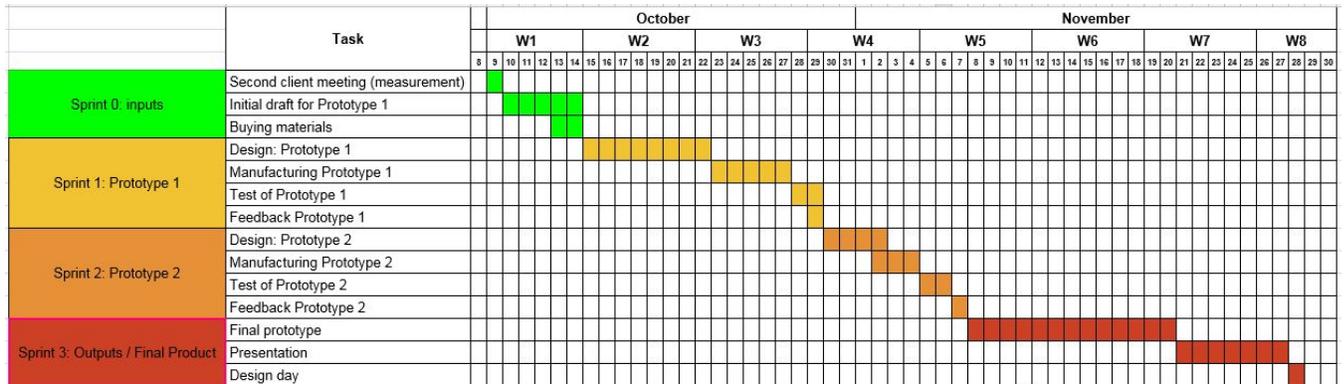


Figure 3. Gantt Chart

## 6 Analysis:

Through research, benchmarks were set for our product to be able to replicate the force of a human hand while executing separate pinches. A squishable newton meter was used to verify our force generation from the servo with these data sets taken from

Table 3. Summary of strength and variability in each of the finger couplings and for simple grip classified by gender.

Gender	Measure	Poke	Press	Pull	Lateral	Chuck	Palmar	Grip	
Male	Mean (N)	52.58	50.90	70.84	97.02	95.37	62.88	452.44	
	Standard Deviation (N)	18.01	18.37	27.16	27.67	28.26	19.20	102.94	
	Coeff. of Variation (%)	34.25	36.08	38.34	28.52	29.63	30.54	22.75	
	Mean (N)	39.31	35.20	49.33	64.84	64.13	45.45	288.91	
Female	Standard Deviation (N)	14.94	14.93	17.71	17.52	19.94	13.90	61.33	
	Coeff. of Variation (%)	38.00	42.42	35.91	27.02	31.10	30.59	21.23	
	Age	Measure	Poke	Press	Pull	Lateral	Chuck	Palmar	Grip
	18-29 (n=61)	Mean (N)	44.27	41.60	57.57	78.93	77.88	51.95	359.91
	Standard Deviation (N)	18.12	18.54	23.77	28.96	28.42	17.76	114.55	
	Coeff. of Variation (%)	40.93	44.58	41.29	36.69	36.49	34.18	31.83	
30-39 (n=19)	Mean (N)	48.69	44.35	63.76	85.49	86.06	59.32	449.45	
	Standard Deviation (N)	16.09	16.89	23.87	27.06	30.02	14.85	104.53	
	Coeff. of Variation (%)	33.04	38.08	37.44	31.65	34.88	25.04	23.26	
40+ (n=20)	Mean (N)	48.46	46.24	64.28	82.69	79.45	56.01	328.64	
	Standard Deviation (N)	18.40	19.84	30.73	27.40	30.24	24.48	109.51	
	Coeff. of Variation (%)	37.96	42.92	47.80	33.14	38.06	43.70	33.32	

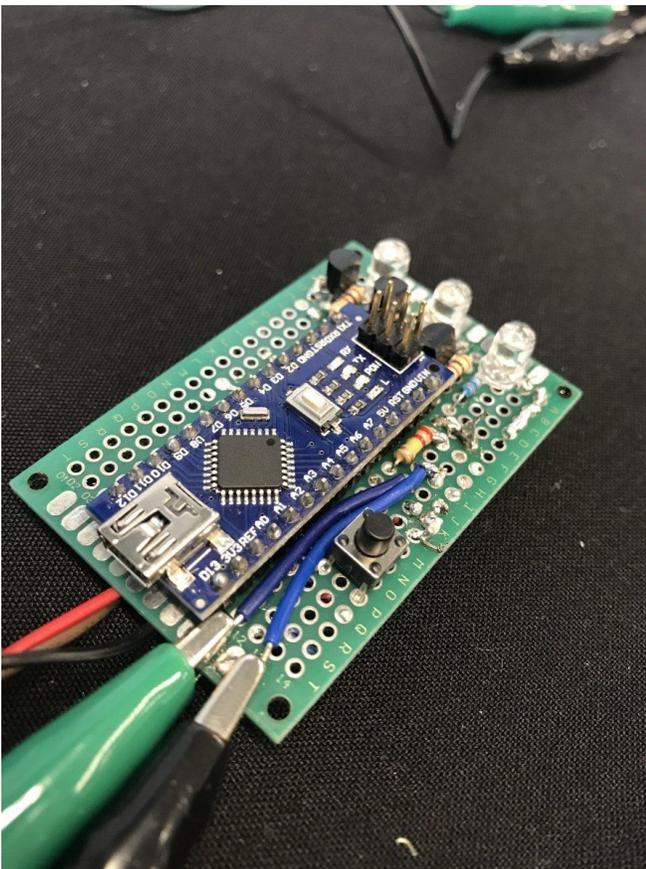
## 7 Prototyping, Testing and Customer Validation.

Following the second client meeting we received the following feedback,

- Device should be as minimal as possible to not interfere with daily hand function of client.
- Device should be able to generate at least 10 newtons of lateral force during a pinch movement with the the thumb and index finger.
- Device should be able to provide consistent support for extended periods of time
- Device must be focused on improving our client's fine motor skills.

Our client was very satisfied with our final product presented on design day however she did mention we could still make the design more minimal and less intrusive

## 8 Final Solution



## 9 Business model

We will use the B2B business model. It is the best choice for our product because instantly when we develop our augmented thumb grip it will hold tremendous appeal but a very niche one. This way by selling our product mostly to hospitals, physiotherapy centers and other medical device specialty retailers we don't have to worry about marketing and tracking down potential consumers as the hospitals will do most of the work for us. This will allow us to constantly produce large quantities of our device even if the other business takes a chunk out of our profits we will still be better off because of the sheer volume of device we will be producing/selling

The biggest and most important assumption we have to when going with the B2B business model is that there will be a significant demand for this product in hospitals, retirement homes, and medical device retailers to justify the profit cut they will take. This is a reasonable assumption because our augmented thumb grip will be the first of its kind for helping patients with muscular dystrophy. Muscular dystrophy in the hands can be caused by a multitude of different diseases and catastrophic injuries so we believe it is in the hospitals best interest to acquire these devices for their patients

Fundamentally our solution boils down to three elements the;

Problem hypothesis:

The problem arises from a missing in relatively inexpensive products that help improve the quality of life of people with problems in movement and strength of their thumbs or fingers.

Solution hypothesis:

It was found that the solution must be a low-cost product with customizable characteristics at the size of the client's hand. This product should be sold to hospitals along with advice to physiotherapists so that they can use the product's guarantees and the types of users that can use it.

Customer hypothesis:

It is inferred that our clients are hospitals specialized in the treatment of patients with muscular and nervous degenerative diseases. These hospitals must have a physiotherapeutic service where the product is formulated and sold

## Canvas Business Model

<b>Key Partners:</b> -3D printing facility -Microcontroller manufacturer (similar size and functionality to an Arduino Uno) -Servo motor manufacturer -Miscellaneous electrical components distributor (wires, transistors) -Screws & bolts distributor	<b>Key Activities:</b> -Manufacturing high-quality products -Distribution to hospitals. -Customization of products. - Maintenance.	<b>Value Proposition:</b>  <b>Low cost, ease to use and highly configurable thumb grip gloves</b> that will allow people with muscular dystrophy in their hands to regain complete control and strength in their thumbs	<b>Customer Relationships:</b> -Low maintenance costs -Easily accessible replacement parts. - easy customization	<b>Customer Segments:</b> -People who have had strokes and suffer from muscular dystrophy -People who have had catastrophic injuries that resulted in nerve and muscle tissue damage that still suffer from muscular dystrophy
<b>Key Resources:</b> -Expert in muscular dystrophy and orthotics			<b>Channels:</b> -Consult with physiotherapists who formulate the product. - Clinical services. - Sale on web page.	
<b>Cost Structure:</b> - Strict budgeting and allocation of costs - Manufacturing Plant in Canada. - We will seek subsidies from charitable groups targeted at stroke survivors to fund our R&D department			<b>Revenue Streams:</b> - Hospitals - Retirement homes -Brick & mortar and online medical device retailers	

### 10 Economic Analysis

<b>Variable Costs</b>	- Ninjaflex 3D print material usage - Circuit board usage
<b>Fixed Costs</b>	- 3D printer time rental - Makerspace lab time rental
<b>Direct Costs</b>	- Labourers to develop circuit boards - Labourers to assemble parts
<b>Indirect Cost</b>	- Labourer safety prime

Table 1: Breakdown of Costs

- Using a NPV analysis, determine the break-even point (it is highly unlikely that your operating income will be positive in the first year because of fixed costs).

$$NPV = \sum_{t=0}^n \left( \frac{R_t}{(1+i)^t} \right)$$

$R_t = 635$  or  $635/12$  per month

$i = 8$  percent per year or  $0.66$  percent per month ( $0.0066$ )

t = 12 (because 12 months in a year)

= **586.80** (For first year)

Based on the following income statement and the following assignments,

- We assume that our workers wont demand more than minimum wage
- We assume that rates for space rentals will remain constant throughout operations
- We assume that the discounted rate of return will remain constant

<b>3 Year Income Statement: HandGrip Tech</b>			
Year	1	2	3
Revenue/Sales	1835	2250	4005
Cost of Goods	1000	1100	1300
Gross Profit	835	1150	1705
Operating Expenses	200	150	100
Operating Income	635	1000	1605

Table 2: Income Statement

## 11 Conclusions and Recommendations for Future Work

There are a few solutions on the market right now but our product has the unique advantage of using low cost technologies that are readily available making our device easy and cheap to manufacture.

A lot of people suffering from these kinds of problems may not have upwards of 10 000 dollars to pay for rare super specific devices which is why we believe we have a huge advantage in the market.

We would like to make our product public domain instead of filing a patent. We firmly believe that our products potential as a revolutionary medical device should stay open source to allow other your entrepreneurs to innovate and expand on our idea without restricting there access with legal patents.

## 12 Bibliography

Xu, K., Li, Q., Mei, T., & Wu, T. (2004). Estimation of wrist force/torque using data fusion of finger force sensors. *Measurement*, 36(1), 11-19. doi:10.1016/j.measurement.2004.04.006

Koiva, R., Hilsenbeck, B., & Castellini, C. (2012). FFLS: An accurate linear device for measuring synergistic finger contractions. *2012 Annual International Conference of the IEEE Engineering in Medicine and Biology Society*. doi:10.1109/embc.2012.6345985

## **APPENDICES**

### **APPENDIX I: User Manual**

The user manual must include the features of the product.

- Insert wrist into glove then gently slide the plastic piece over your thumb ensuring the touch sensor is placed over the tip of your thumb.
- Check if the batteries have power
- When you want to activate the force grip capabilities firmly use your forearm to guide your hand and press your thumb on the object you wish to grab
- When you want to deactivate the force grip capabilities make sure the object you were gripping is placed down on a solid surface then with your other fingers (not your thumb) release the object and slide your thumb off so the touch sensor is no longer activated
- Rinse and repeat

Functions and the capabilities of the product

- Can generate torsional force along the ulnar collateral ligament
- Touch sensor activated by applying a force greater than 3 Newtons

### **APPENDIX II: Design Files**

The following link leads to a Google Drive folder with all the relevant project files. Each file is named according to its function.

<https://drive.google.com/open?id=126I19FCKscRFMcXVUApvBNSIXqZSaeFR>