Helping Hands

Trine University
Biomedical Engineering

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J.C.INNOVATIONS

Introduction:

The Trine University senior design team partnered with JC Innovations to develop passive, 3D printed upper limb prosthetics for two girls from Warsaw, Indiana. This project is a continuation from the Spring 2020 special topics course. Both girls were born with left congenital hand deformities and had no prior prosthetic devices. The girls wanted to increase their independence by performing everyday tasks like riding a bicycle, brushing their hair, and washing dishes. The team used this information to design and manufacture functional 3D printed prosthetics. 3D printing prosthetics is a more affordable option for families with growing children since a child could need up to six prosthetics while they are growing. Using e-NABLE, an online forum designed for people to share their ideas and designs for 3D printed prosthetic hands, the team was able to select the Phoenix Hand v3 to begin the design process.

Figure 1: Girl #1

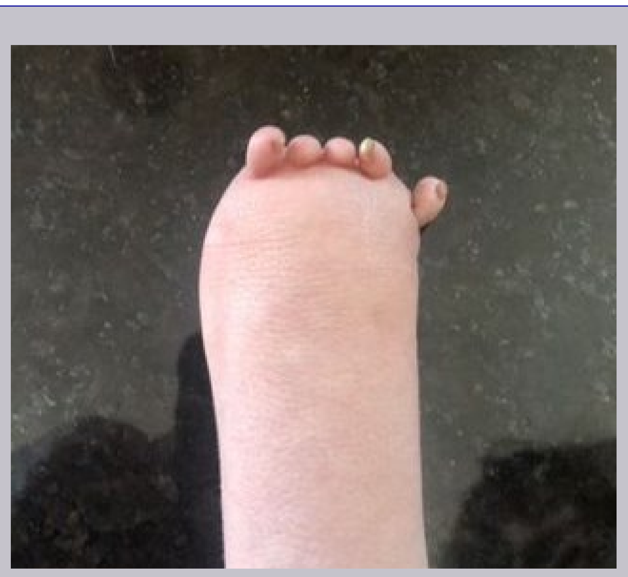

Figure 2: Girl #2

Material Selection and Validation:

Material requirements included high strength, high durability, thermoformable, and it had to be compatible with the available 3D printers. The Helping Hands Senior Design Team selected Glycol Modified Polyethylene Terephthalate (PETG) as the 3D printing material. PETG is a commonly used plastic making the whole device recyclable once it reaches the end of its life. Chemical resistance testing (set up shown in Figure 3), tensile testing, bending testing, and wear testing (apparatus shown in Figure 4) were all performed by the senior design team to validate the material selection. Material testing protocols were based off ASTM standards including ASTM D638: Plastic Tensile Testing, ASTM 7264: Standard Test Method for Flexural Properties of Polymer Matrix Composite Materials, ASTM D543: Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents. PETG met all the requirements, and it is a viable material for this project.

Figure 3: Chemical Resistance

Figure 4: Wear testing

Design Process:

The prototype design concept was based off the e-NABLE Phoenix Hand v3. Other ideas were selected from various Phoenix Hand models, the Cyborg Beast and the Flexy-Hand 2. All parts were sized to fit their residual limb and be comparable to the girl's right hand. The grated portion on the underside of the palm was designed to be thermoformable for increased comfort and better fit. After distribution of the prototypes to the customers the Helping Hands Senior design team received feedback and began making design changes. Some design changes included:

- Fine adjustments in sizing
- A new tension system to improve gripping abilities
- The addition of a locking mechanism using wing nuts
- The addition of fingernails to the proximal parts for aesthetic purposes
- The incorporation of universal parts between Girl #1 and Girl #2

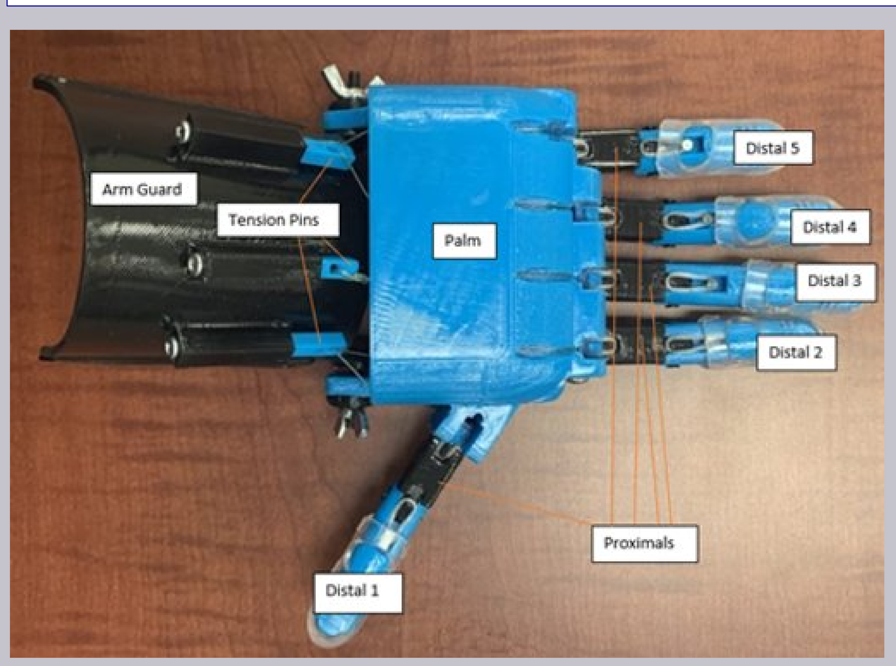

Figure 5: Final 3D Printed Device

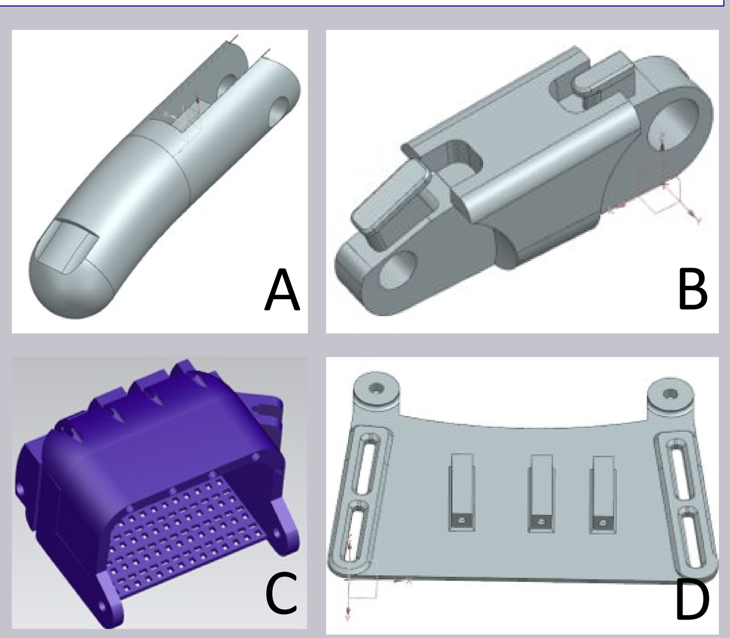

Figure 6: (A) Distal part, (B) Proximal part, (C) Palm, and (D) Arm Guard

Figure 7: Tension System

Figure 8: Girl #1 Final Device vs. Prototype

Figure 9: Girl #2 Final Device vs. Prototype

Assisted Grip Device:

This small device was designed to attach to small, common objects using a Velcro strap. The device consists of a 3D printed part shown in Figure 11 and Figure 12, two round, ceramic magnets, and a Velcro strap. The magnets are attracted to the stainless-steel plate attached to the palm of the hand design shown in Figure 10.

Figure 10: Stainless Steel Plate

Figure 11: Grip Device

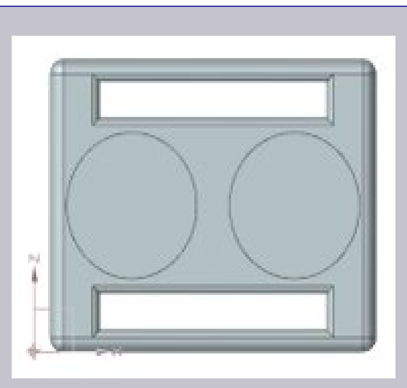

Figure 12: Grip Device

Functional Validation Testing:

Validation testing was performed to evaluate the usefulness of the prosthetic devices. Grip validation and validation using sensors was performed. The girls were evaluated at the initial fittings of the prototype and the final design and again at 1 and 2 weeks after the prototype fitting. Sensor validation was performed at the fitting of the final device. Table 1 shows the progress made on the grip validation, Table 2 shows sensor validation, Figure 13 shows the circuit used for the sensor validation testing and Figure 14 shows the validation curve.

Table 1: Grip Validation Data

	Prototype Fitting Score	Final Device Score	Percent Improvement
Girl #1	9	25	178%
Girl #2	13	25	92%

Table 2: Sensor Validation Data

	Goal Measurement	Actual Measurement	Percent Over Goal
Girl #1	9.62 N	11.1 N	15.4%
Girl #2	9.62 N	10.2 N	6.0%

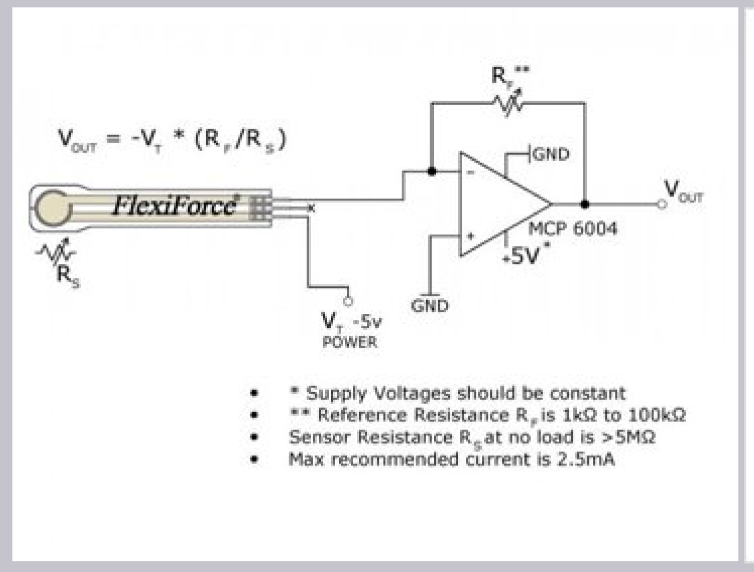

Figure 13: Sensor Circuit

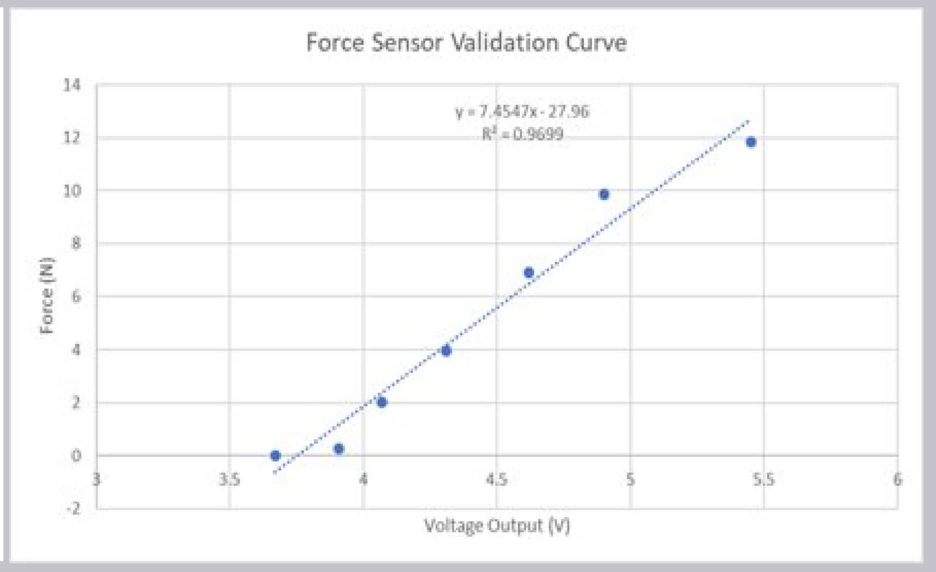

Figure 14: Validation Curve

Recommendations for Future Work:

Based off the team's experiences recommendations include:

- Begin 3D printing sooner.
- 3D print at a lower fill compared to the 80% the team used to decrease the overall mass.
- Double check all measurements to ensure a correct initial fit.

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- J.C. Innovations https://jc-innovations.com/helping-hands/