Design of an Ergonomic Tool for People With Upper Limb Prosthesis

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1 INTRODUCTION

A hand prosthesis user was identified as the main subject for this project. He will serve as the individual for whom the device will be designed. The client went through bilateral amputation on his upper limbs below the elbow. He has been using opening split hooks prosthesis on both arms for the last three years. Tasks that require certain degree of precision or movement are out of his capabilities. The development of this design intends to increase prosthesis functionality and foster independence in daily activities.

2 PROBLEM STATEMENT

Currently the client leads a highly independent and functional lifestyle. The use of the prosthesis permits him to perform most tasks involved in a daily routine. Yet, the task of changing a light bulb is out of the scope of his abilities. This serves as the motivation to design a device that theoretically will allow the user to change a light bulb considering the limitation of the prosthesis.

3 OBJECTIVE

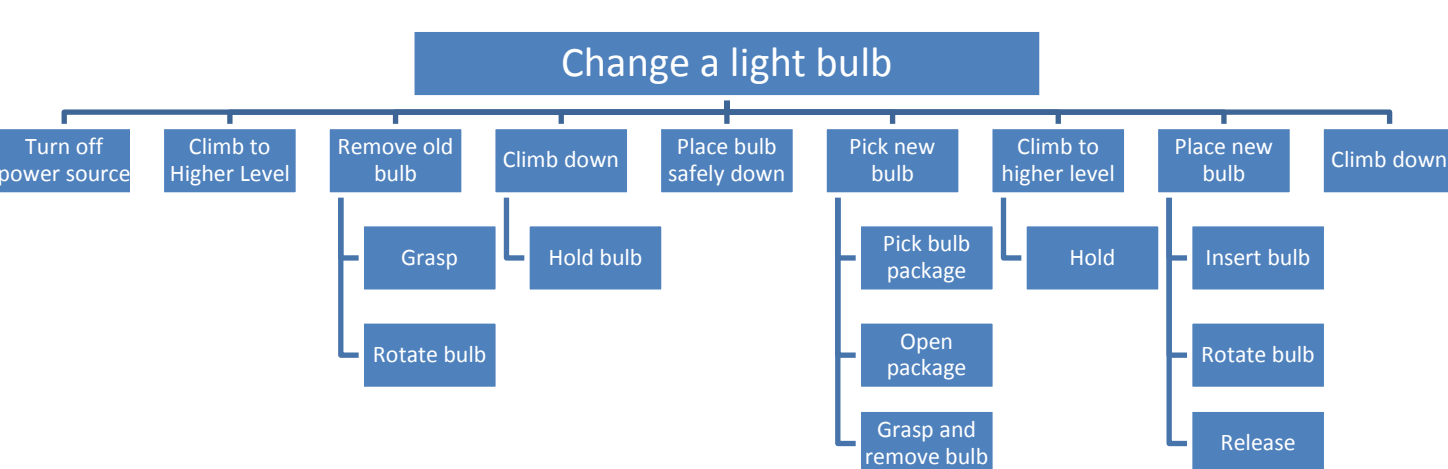Design an ergonomic tool that allows a hook prosthesis user to change a light bulb.

4 METHODOLOGY

OVERALL PROJECT FLOW CHART

Conceptualization → Preliminary Detailed Design → Cost Analysis

CONCEPTUALIZATION

Task Analysis:

Risk Assessment Decision Matrix:

| PROBABILITY	SEVERITY				
	I	II	III	IV	V
Frequent					
Probable					
Occasional					
Remote					
Improbable					

Specifications:

Research Findings:
- Client Interview
- Anthropometric Evaluation
- PI's Requirements
- 3D Printer Expert Interview
- Machine's Manual & Specs
- Task Analysis
- Therapist Orientation

Specs Model:
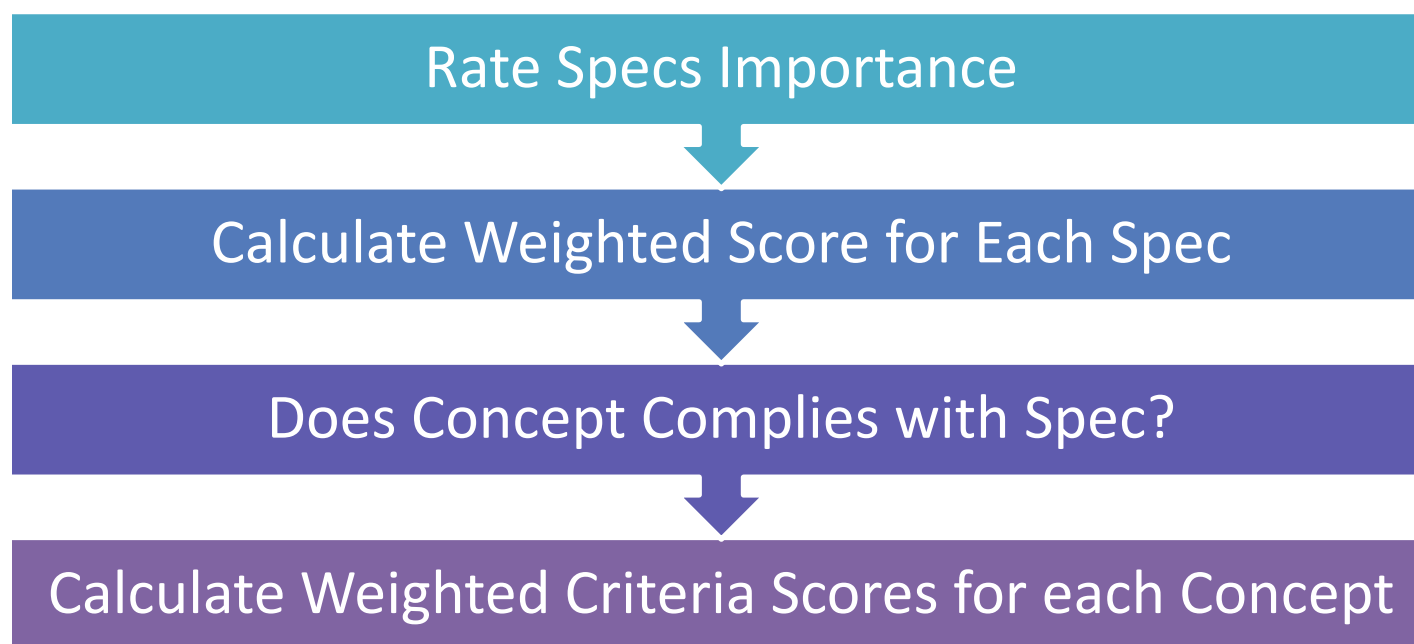- Performance
- Technical
- Customer
- Manufacturing
- Environmental

Brainstorming:

Project Analysts / High School Students / Mechanical Engineering Experts
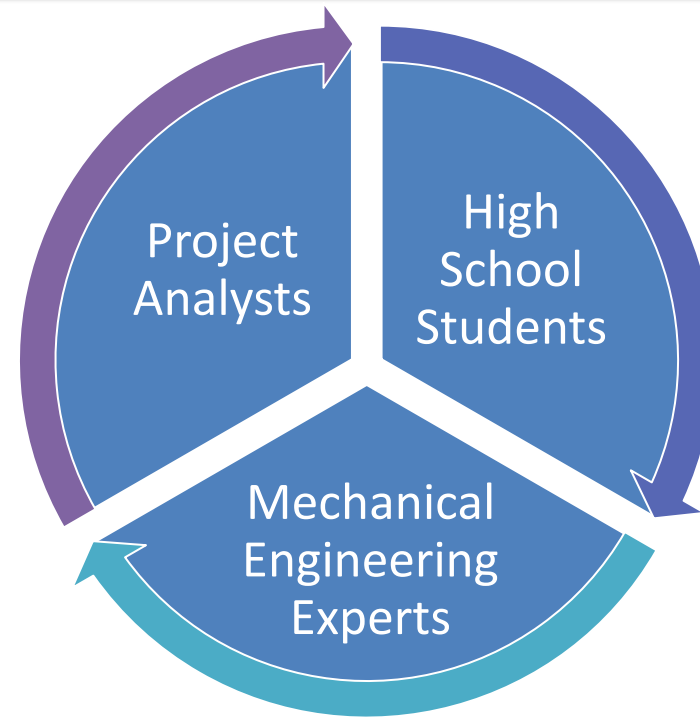
Discretizing & Morphological Analysis:

ACTIVITY	CONCEPTS
Handle	
Extend	
Align	
Rotate	
Grab Bulb	

Weighted Criteria Assessment:

- Rate Specs Importance
- Calculate Weighted Score for Each Spec
- Does Concept Complies with Spec?
- Calculate Weighted Criteria Scores for each Concept

DETAILED DESIGN

Design for Usability:

Ergonomic Analysis for Handle Dimensions
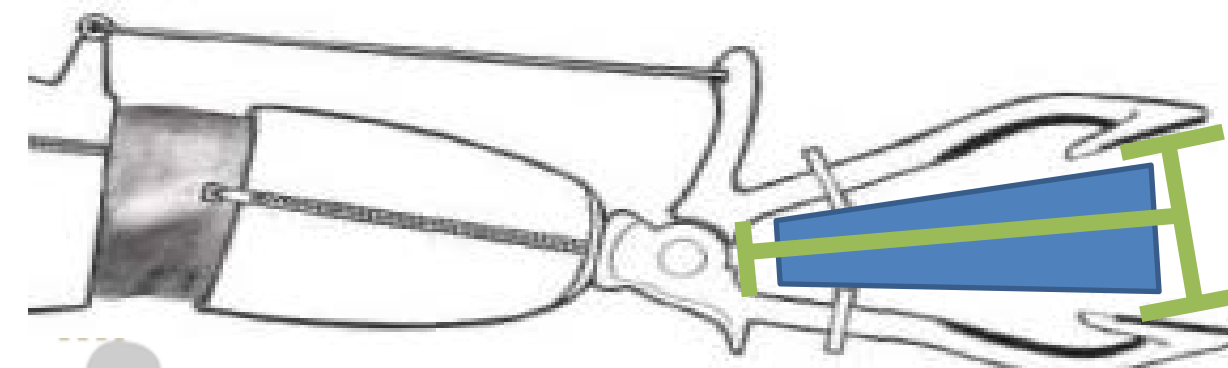
Anthropometric Data for Tool Length

MEASURES	PERCENTILES	
	1 – Women	99 - Men
Standing Height of Elbow (cm)	91.30	121.52
Standing Height of Eye (cm)	134.78	177.56

Failure Analysis:

FAILURE SCENARIOS	DESIGN DECISIONS
Assembly Breaks	Material Strength Analysis
Dimensions don't fit	Press Fit Interference Tolerance
Grip force breaks tool	Material Strength Analysis
Tool slips from grip	Cubic shape; Handle Support
Pulling force exceeds tolerance	Force Analysis
Bulb does not rotate	Suction cup
Device cannot hold the light bulb	Holder height exceeds half the bulb's length

5 RESULTS

Champion Selection:

SPEC CATEGORY	WEIGHTED SCORE			
	C1	C2	C3	C4
Performance	45	45	45	45
Technical	77.1	77.1	77.1	77.1
Customer	66.6	74.3	73.3	83.5
Manufacturing	45.2	45.2	22.3	45.2
Environment	12	12	12	12
TOTAL	245.9	253.5	230.6	262.7

Final Design:

99 Percentile   1 Percentile
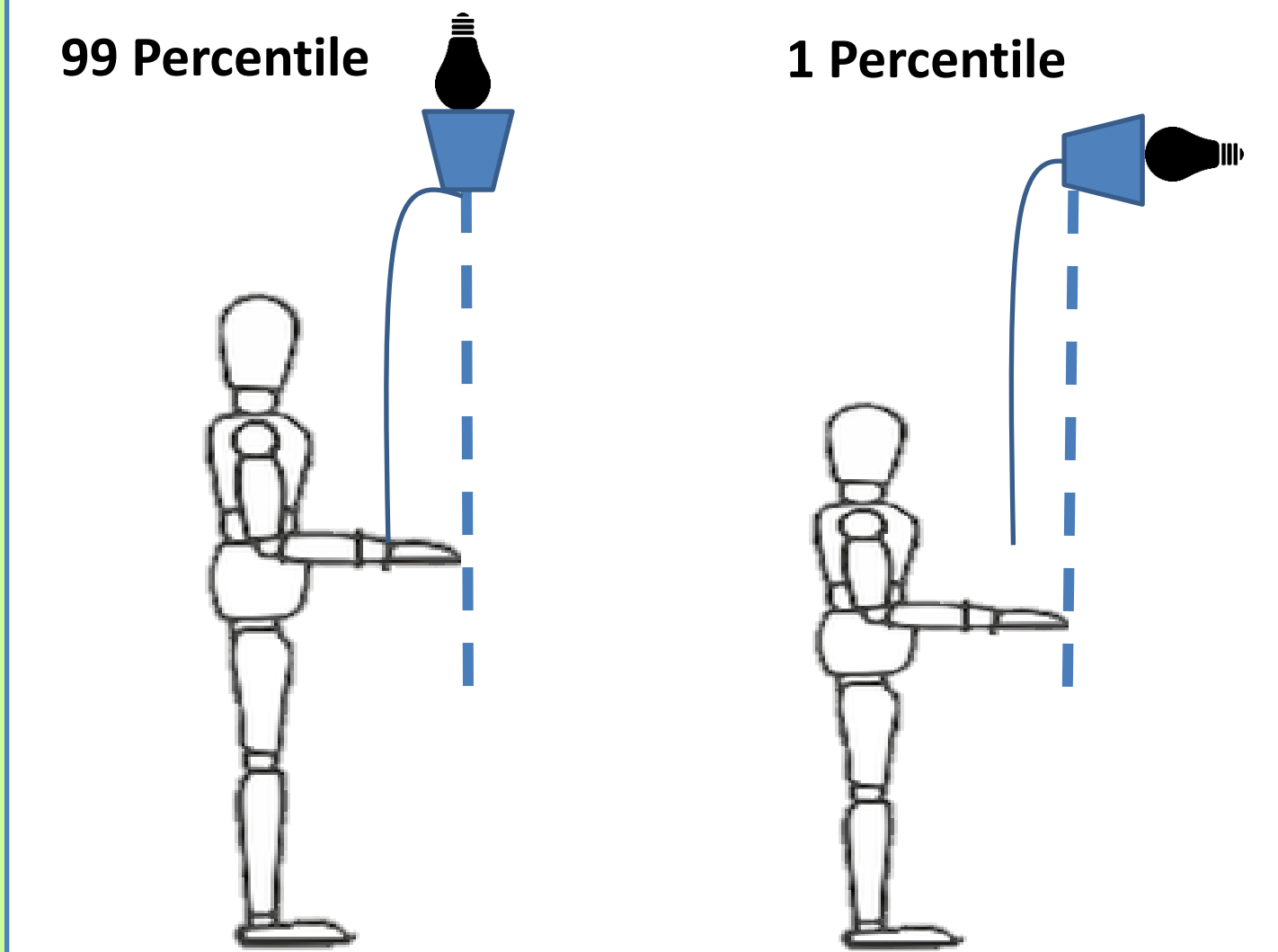
Cost Analysis:

COST ACCUMULATION	COST MEASUREMENT		COST ASSIGNMENT
PLA Filament	DM	$28.30	
Adhesive		$0.90	
Cord		$0.23	
Friction Material		$2.97	$365.24
Warning Label		$0.27	
Recoil Winder		$9.99	
3D Printer Operator	DL	$302.40	
Utilities	OH	$6.16	
Maintenance		$0.28	
Depreciation		$13.74	

6 CONCLUSION & FUTURE WORK

- This project showcase the necessity of devices that target people with prosthesis and enables them to realize everyday tasks.
- The 3D printer technology available is too costly for the production of this product, due to the amount of time it takes and the associated operation costs.
- Methodology used includes the perspective of all the stakeholders involved in the design process to develop a device that meets all ergonomic requirements.
- A thorough mechanical analysis will be realized to ensure the assembly stability and start the final testing of the prototype.

7 ACKNOWLEDGEMENTS

ingeniería industrial UPRM

Advised by: Dr. B. Rodríguez

Industrial Engineering Capstone Project