

Exoskeletons – Designing for Social Justice

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Abstract

Many engineering professionals believe that discussions surrounding diversity, equity, and inclusion (DEI), and social justice do not belong in engineering because engineering is supposed to be a neutral or objective field. Through an extensive review of the literature and a survey sent out to potential users, the need for DEI in engineering was examined. Many current engineering projects do not take into consideration social justice principles which leaves certain groups further marginalized and disempowered while empowering a select few. Engineering has the opportunity to be a field of service, but first risks and benefits must be weighed and the outcome of enhancing human capacities must be valued over monetary gain. For example, this project was dedicated to applying DEI efforts to engineering an upper limb exoskeleton. In this case, the exoskeleton enhances a person’s capabilities by enhancing their natural arm movement. In order to equitably design our exoskeleton we considered user needs from the very beginning through empathy mapping and surveying potential users. The results that we have gathered thus far suggest that potential users care foremost about cost and secondly about the comfort and fit of the device. Moving forward it is crucial that we implement design choices that reflect the value of the potential users to ensure that the device we create is attainable and usable while offering a sustainable solution to users.

History of Engineering With a DEI Focus

1712 - Invention of the Steam Engine

The invention of the steam engine allowed for the mass production of material goods and a boom in the engineering industry. While the number of engineering professionals increased to manage the machines, so did child labor, poor working conditions, and unemployment rates.

1914 - Start of WWI

During war time, the engineering profession experienced a shift from focusing on producing material goods to feed America’s consumerism culture to production to fuel the United State’s vast military. This trend continued with WWII and other military conflicts that the US was involved with.

1957 - Sputnik

The launching of Sputnik created a new technical urgency within the engineering field in the US to not ‘fall behind’ the Soviet Union during the Cold War. This ideology furthered the field’s laser focus on engineering’s required technical skills while overshadowing softer skills that contribute to the just and sustainable application of engineering.

Today

The vast majority of engineers work either serving a large for-profit corporation that feeds into America’s capitalist and consumerism focused society or for a military focused company. Very few engineers will work a full-time job focused on serving communities and sustainable, human-focused projects.

Figure 1: Timeline depicting relevant events throughout the development of the engineering profession

Humanitarian Engineering

Key elements of Humanitarian Engineering

- Humanitarian Engineering promotes social justice and focuses on empowering marginalized and underprivileged individuals and communities.
- Must understand the location, knowledge, and desires of an individual or a community in order to form trust, open communication, and an authentic mutual relationship.
- When individuals or communities are empowered and feel in control of the technologies that they are using the project is ultimately more sustainable and valuable long term.

Social Justice in Engineering

Engineering for Social Justice Criteria

Listen Contextually ~ Identify Social Conditions ~ Acknowledge Political Agency and Mobilize Power ~ Increase Opportunities and Resources ~ Reduce Imposed Harms and Risks ~ Enhance Human Opportunities

- Systemic issues exist within engineering such as misogyny, racism, and classism. Since engineering boomed as a very exclusive field many individuals who identify with an underrepresented group feel ostracized by the field leading to high drop out rates.
- Engineers must be experts about social justice within their field because if they aren’t then no one is.
- In order to work for true social justice, there must be institutional change that fundamentally challenges the foundation of engineering.
- Historically, engineering has mirrored the values of the mainstream society including neoliberalism, military and corporate interests.
- Many engineers claim that they are apolitical or value neutral which leads to continued inequality within the field, specifically in regards to who benefits and who is harmed.

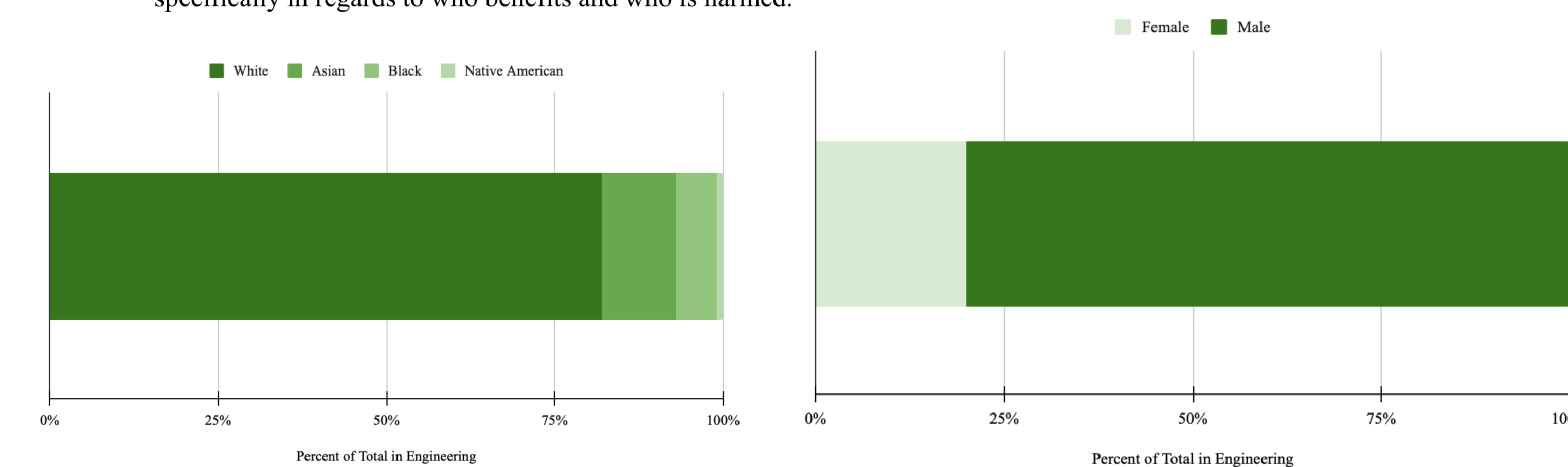


Figure 2: Composition of folks in engineering, depicted skewed ratios of minority groups

Design Framework

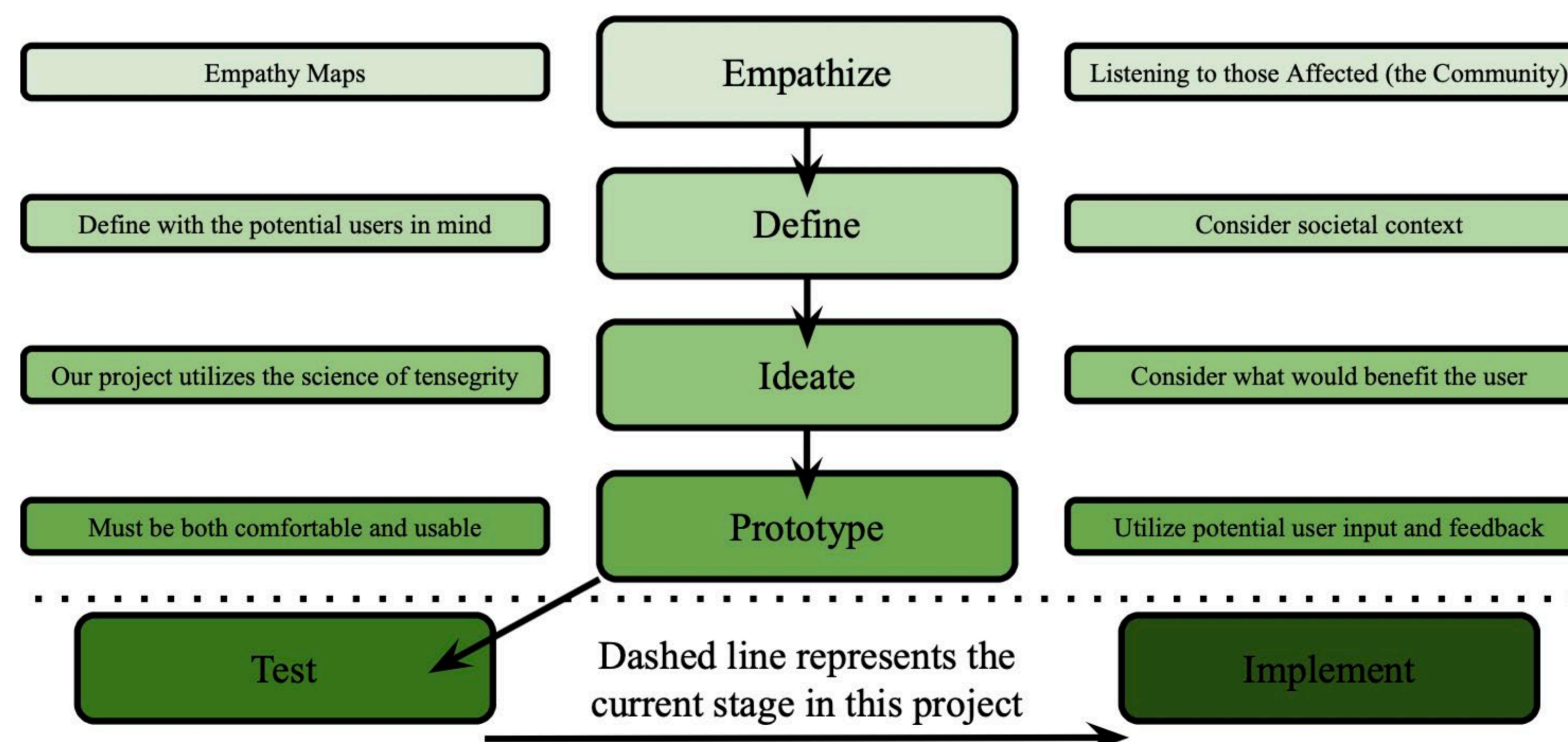


Figure 3: Depiction of the design framework that has been used and will be used in future development of the exoskeleton

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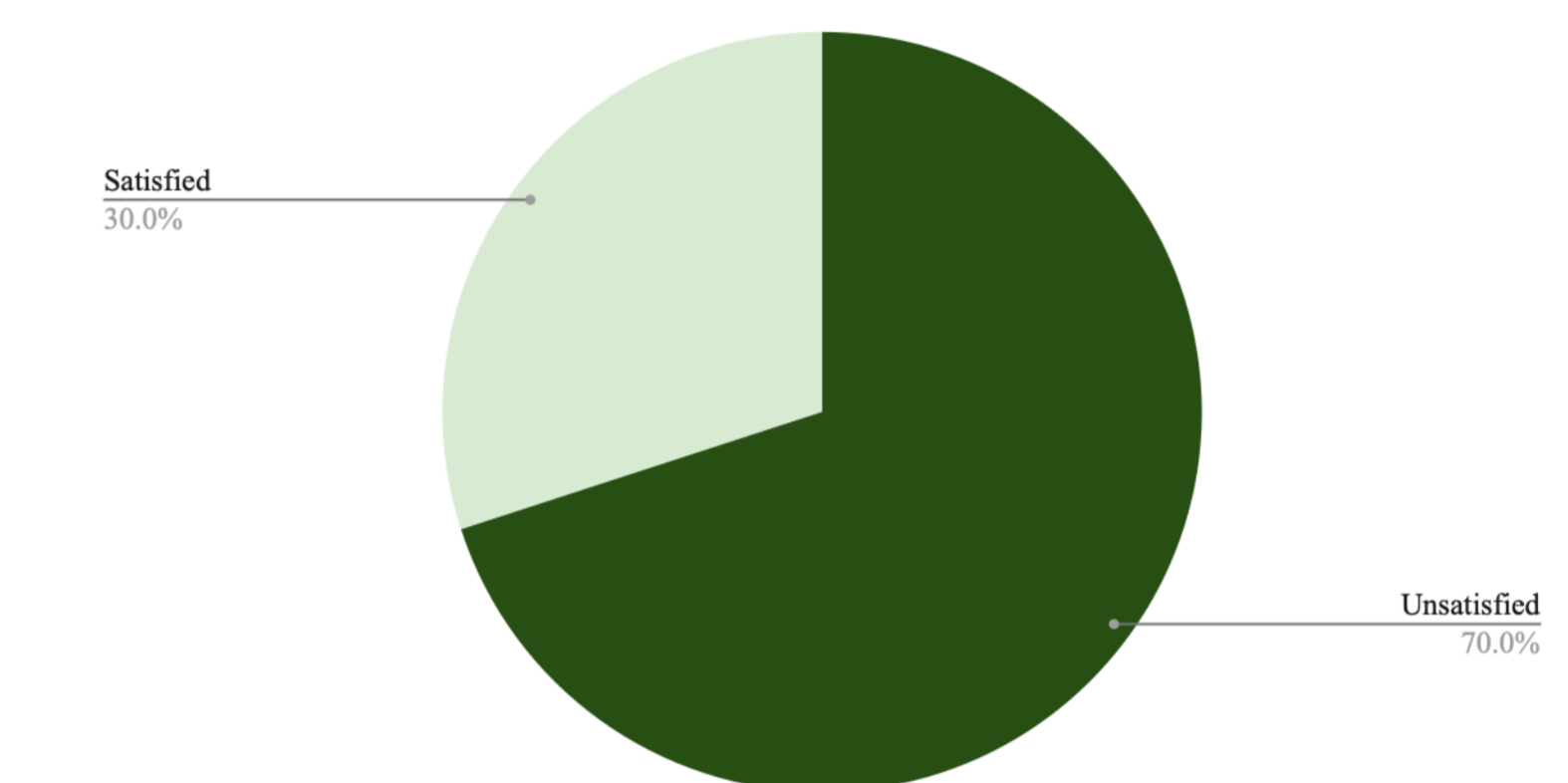
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User-Specified Design

Why is User-Specific Design Important?

- Engineering currently mirrors the mainstream society which isn’t representative of all the potential users that the products of engineering hope to serve
- Engineering has developed as a way to serve our country’s militaristic and materialistic needs,, therefore, the vast majority of engineers do not know how to design with a community in mind

Prosthetic Limb Satisfaction Rate



- When designing for potential users the 3 E’s must be considered: ecology, economy, and equity to avoid producing unsustainable designs
- Engineers must consider the ethics of care and must be attentive, respectful, responsive, and competent. Failure to do so can lead to injustice.
- During the ideate stage engineers should ponder the following questions. The best way to gain an answer to these questions is to engage with the community of potential users.
 - What does the user need?
 - What does the user care about?
 - Why is this important to the user?
 - What emotion is guiding the user’s feelings?

Results of User Needs Survey

Factors ranked in order of importance for users

1. Cost
2. Comfort/Fit
3. Donning/Doffing
4. Efficacy (amount of independence the device provides)
5. *Weight/Bulkiness | Ease of transport | Ease of repair

*The above three factors all were valued equally with respect to each other

Next Steps

Phase of Design	Steps to be Taken
<i>Ideate/Prototype</i>	<ul style="list-style-type: none"> • Perform additional research and implement data gathered from responses <ul style="list-style-type: none"> • User interviews and qualitative surveys
<i>Test</i>	<ul style="list-style-type: none"> • Quantitatively and qualitatively analyze users’ ability to put on the device • Listen contextually to user’s feedback and empower them in the design process
<i>Implement</i>	<ul style="list-style-type: none"> • Adapt designs based on feedback gathered • Be open to gathering more feedback from a more diverse group of people that accurately represents the diversity of potential users