Halo

Vision Care System

Industrial Design Thesis Dossier - Justin Ho

Improving Access to Vision Care Services in Rural Canada

by

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Abstract

Though technological advancements have been made in vision care, many rural low income communities still lack access to even the most basic services. The main challenges with accessing these communities is that they tend to be spread far apart from each other and they usually have less money to be able to spend on services like vision care. As such it is not very viable for businesses to operate there. Vision care is important for communities as proper vision is often required for safely and effectively completing everyday tasks like driving, studying, and working. Existing solutions work infrequently and significant time commitments from customers who may not work consistent hours or do not work traditional jobs. The dependence on subsidies and charitable foundations for financing these services also limits how reliable these services can be.

The aim of this thesis project is to develop a product that can help populations living in rural low income communities to easily and reliably receive vision care; while also being affordable and considerate of the time of the customers. To develop an effective solution, research was undertaken to develop a profile of the major user groups and to better understand the circumstances of the market. Experts in the field were consulted to understand back-end logistical issues and similar users were also surveyed to understand their needs.

Acknowledgements

I would like to thank my family and especially my parents for supporting me through my degree and funding it. They have always been supportive of my career path. I would also like to thank my mentors Newton and Dorothy for guiding me through the program; giving me wisdom and courage. I would also like to thank my good friend Tim, my sister, Gabriel, and Newton again, for keeping me distracted when I was stressed out from this program. Finally, I would like to thank Charis and Philip for helping me develop a suitable portfolio to get me in this program in the first place.

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CHAPTER 1 - Introduction
Background and Significance

1.1 Problem Definition

Though vision care has advanced significantly, most common vision correction aids such as glasses remain inaccessible to most. They require a significant amount of adjustment by professionals to form a good fit. The lack of other eye care services in certain regions can also cause preventative diseases to go unnoticed for individuals in some communities. Vision correction services are currently prohibitively expensive. This can mean that low income households may settle for lackluster eyewear solution or forgo it entirely. Despite advancements in manufacturing and online interaction, the industry has stayed largely the same.

Without proper vision correction services, visual impairment could cause individuals to cause harm to themselves, harm to others, or damage to property as a result of their poor vision. Especially if users choose to operate vehicles or complete work while not receiving vision correction. Ocular illnesses could also develop into more serious health complications if not addressed.

1.2 Rationale & Significance

Determining what the main needs of the primary and secondary users is a great priority in developing a solution. Looking at existing solutions and trying to understand why other attempts at ameliorating this problem have failed will also give good insights into the logistical and the financial constraints of developing a solution that can be economically viable.

There are several design constraints that need to be considered before advancing into the design phase. Factors such as the main types of equipment that are needed for eye exams, the requirements for them to function, what they accomplish, and the special considerations they need when put in transport. Understanding the motivations of users and why existing solutions are not acceptable for them is also an important subject of interest. This includes their existing pain points and also their reasons for not accessing existing eye care services.

To research the topics previously mentioned, several strategies will be used in order to gain a comprehensive understanding of the problem and the topic. First, literary reviews of existing quantitative and qualitative data will be done. Then, more general information from the web such as blogs and product reviews will be completed to gain the perspective of what an average user may come across when researching the topic. Finally, users and experts in the field will be contacted to complete interviews, surveys, and user observational studies. Once the information is gathered, it will then be analyzed using activity mapping, empathy mapping, and comparisons charts.

1.3 Background / History / Social Context

Many rural populations around the world have difficulty accessing eye care services and even have difficulty accessing healthcare in general. Even when lower income populations have received corrective eyeglasses in the past, a large portion of that eyewear is likely old, damaged, or not properly cared for. The abundance of low quality eyewear in certain communities can be attributed to unregulated street vendors who sell discounted eyewear. (Ayanniyi et al. 2010) For the populations that do not wear glasses, they may hold a common belief that wearing glasses will actually make their vision worse. (Zhou et al. 2014) Different cultures may have different types of challenges in accessing eyewear. In Indigenous communities in Canada, many individuals have irregular work schedules which make it difficult to make or follow through with appointments for eye exams. Especially as some eye care facilities may be a flight away (OPTIK by/Par VuePoint, Page 34, 2022).

The advancements in mobile computing have made receiving eye exams a lot easier. Equipment such as auto-refractors now come in portable packages while other exams work with the user’s smartphone. In fact, multiple types of testing equipment can even be combined into one machine which reduces the amount of equipment that offices need to acquire.

CHAPTER 2 - Research
Products and Users

2.1 User Research

Having a good understanding of the users and their needs is required to develop an effective solution. To gain insights on these users, interviews, user observational studies and surveys will be completed. Then the data gathered will be analyzed through mapping techniques to determine which information is most important.

Primary User

Low income patients/customers of the eye care services will be the primary user for this solution. This population is generally adults who have full-time jobs, live in remote areas, and lack a means of transportation.

Persona	
Name: David Lancastor Age: 27 Job: Medical Secretary Income: $45 000 Education: College graduate Family: Single, has 1 child Location: Fort Albany, ON Vision Needs: Blue light filtering and myopia correction Solution: Is interested in getting glasses	

Duration: Expects glasses to last 3 years Social/solitary: Mostly with his child or with friends Other Activities: Active lifestyle Involved parent Profile: David Lancastor is 27, is a medical secretary working at a local clinic. He has an annual income of $45 000 and is a single parent of one. He lives in Northern Ontario in Fort Albany. David works at the computer for much of the day and has difficulty sleeping as a result of the blue light from the computer. He also has difficulty seeing some text. David's eyesight has only recently gotten worse.	

Table 1 – User Persona

Secondary User

Medical professionals such as opticians and optometrists are the secondary users. They work with the equipment to help the primary users. They often work regular shifts and require a certain level of education to attain the position.

Tertiary User

Tertiary users would include general maintenance staff which performs upkeep on the eye testing facilities. It would also include family members and friends of the primary user who may accompany them when they visit the eye care facility.

2.1.2 Current User Practice

To evaluate how users receive eye exams, the process they take, and how regularly they receive exams, interviews and surveys was conducted. Users were asked how frequently they look to get new glasses, the reasons they get new glasses, the factors by which they take to get glasses, how they found the experience, and the main factors that prevented them from getting glasses.

The surveys were conducted on Humber College and in person with four students. The results of the survey were that all participants decided that need motivated whether they would get new glasses. They said that the affordability of the glasses and of eye exams prevented them from going to get eye care services more often. Usually users only have one pair of spare glasses which is their previous pair of glasses. Those glasses are generally not the right prescription but will suffice. Users also stated that glasses can last them from 1 – 6 years. The frequency at which they acquire new glasses is heavily dependent on how their eyesight changes over time.

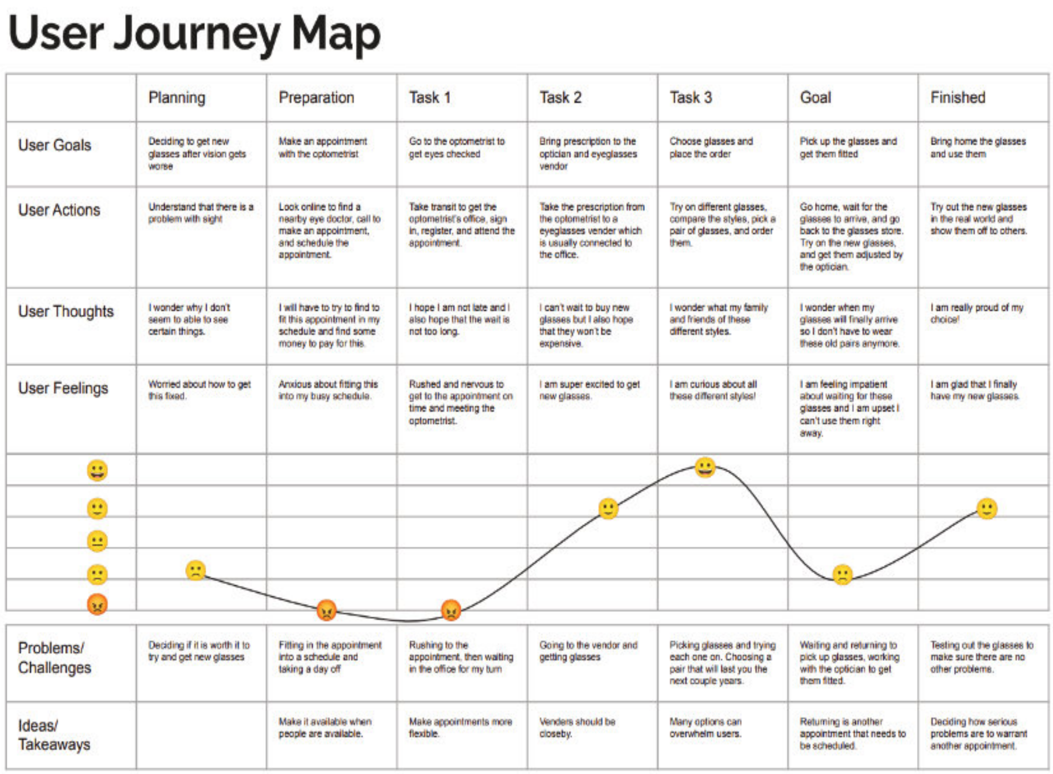
The results of the interview were largely consistent with the findings of the surveys. The interview clarified some other factors that impacted how glasses are chosen. The participant revealed that the appearance and design of the glasses did play a role in which glasses were chosen but did not affect whether or not they would get new glasses. They also revealed that they would not use their old glasses if they didn't have to. They were also not desperate to get new glasses because the style of their existing glasses were still a good fit for whom they are now.

2.1.3 User Observation – Activity Mapping

Within the interview, the participant was asked to go through the process of getting new glasses. This workflow was then analyzed to gain a better understanding of the user's mental state and the problems they encounter when acquiring new glasses.

With the information provided, a user journey map was established where it was determined that the main challenges of getting new glasses were making the appointment and returning for the followup appointment. The different concerns associated with attending and making appointments were also taken into account when the empathy map was made.

Finally, a user observational study was completed with the secondary user as well, the optician. This was done by coding a video of an optician describing their workflow. Opticians working in the workplace tend to spend a lot of time working with customers and there is a strong emphasis on customer interaction. Implementing opportunities for customers and medical professionals to communicate will be a priority.


User Journey Map

	Planning	Preparation	Task 1	Task 2	Task 3	Goal	Finished
User Goals	Deciding to get new glasses after vision gets worse	Make an appointment with the optometrist	Go to the optometrist to get eyes checked	Bring prescription to the optician and eyeglasses vendor	Choose glasses and place the order	Pick up the glasses and get them fitted	Bring home the glasses and use them
User Actions	Understand that there is a problem with sight	Look online to find a nearby eye doctor, call to make an appointment, and schedule the appointment.	Take transit to get the optometrist's office, sign in, register, and attend the appointment.	Take the prescription from the optometrist to a eyeglasses vender which is usually connected to the office.	Try on different glasses, compare the styles, pick a pair of glasses, and order them.	Go home, wait for the glasses to arrive, and go back to the glasses store. Try on the new glasses, and get them adjusted by the optician.	Try out the new glasses in the real world and show them off to others.
User Thoughts	I wonder why I don't seem to able to see certain things.	I will have to try to find to fit this appointment in my schedule and find some money to pay for this.	I hope I am not late and I also hope that the wait is not too long.	I can't wait to buy new glasses but I also hope that they won't be expensive.	I wonder what my family and friends of these different styles.	I wonder when my glasses will finally arrive so I don't have to wear these old pairs anymore.	I am really proud of my choice!
User Feelings	Worried about how to get this fixed.	Anxious about fitting this into my busy schedule.	Rushed and nervous to get to the appointment on time and meeting the optometrist.	I am super excited to get new glasses.	I am curious about all these different styles!	I am feeling impatient about waiting for these glasses and I am upset I can't use them right away.	I am glad that I finally have my new glasses.
Problems/ Challenges	Deciding if it is worth it to try and get new glasses	Fitting in the appointment into a schedule and taking a day off	Rushing to the appointment, then waiting in the office for my turn	Going to the vendor and getting glasses	Picking glasses and trying each one on. Choosing a pair that will last you the next couple years.	Waiting and returning to pick up glasses, working with the optician to get them fitted.	Testing out the glasses to make sure there are no other problems.
Ideas/ Takeaways		Make it available when people are available.	Make appointments more flexible.	Venders should be closeby.	Many options can overwhelm users.	Returning is another appointment that needs to be scheduled.	Deciding how serious problems are to warrant another appointment.

Figure 1 – User Journey Map

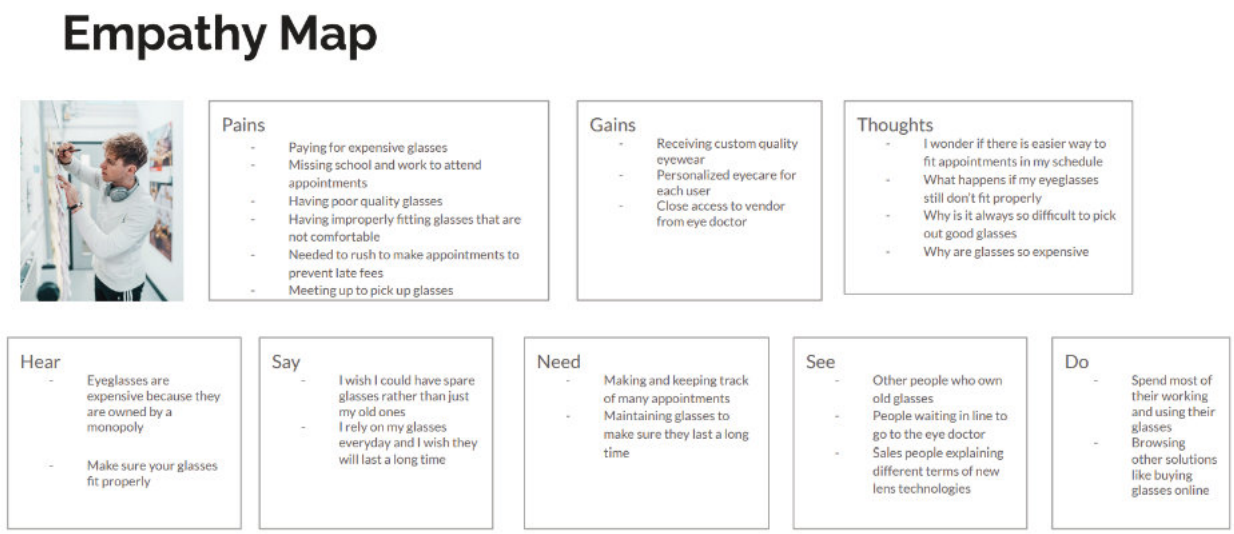
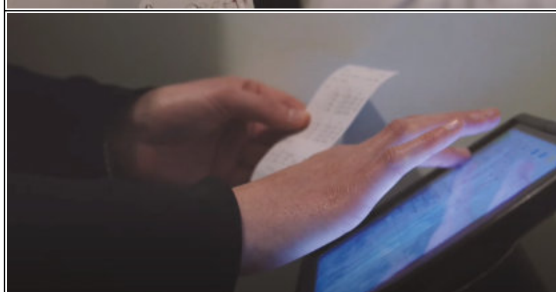
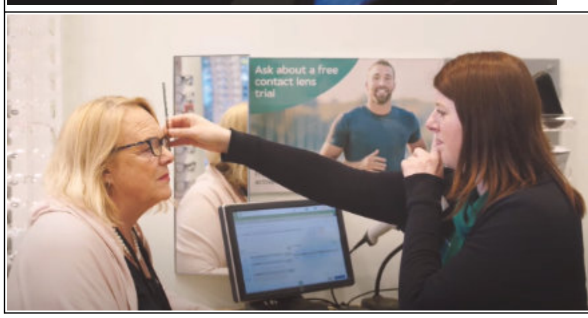


Figure 2 – Empathy Map

User Observational Study - A day in the life of a Dispensing Optician - YouTube	
	Consulting with customers about different styles of glasses and the different options available for purchase.
	Optician entering information into a computer system
	Completing fitting tests of glasses

	Consulting with customers about fit and making adjustments as needed

Table 2 – User Observational Study

2.1.4 User Observation – Human Factors of Existing Products

The process of receiving eye testing requires many ergonomic interactions. During the user observational studies that were completed, there were many pieces of eye equipment that required a certain level of adjustment. Examples of equipment used are phoropters, auto-refractor, non-contact tonometer, slit lamp, reclining chair, and a fundus camera.

The main elements that users interact with are the eyepieces for the equipment, the chin rest, the forehead stopper, and the chair. However, with more compact eye testing equipment, usually only the eyepieces are being used. Eye testing equipment usually takes up quite a bit of room which means that a large office-style room is used to house everything. In mobile clinics, adjustable and folding equipment can be used which will greatly reduce the amount of space required. Even with more compact equipment, mobile clinics tend not to be roomy enough.

2.1.5 User Observation – Safety and Health of Existing Products

New advancements in eye-testing equipment have largely reduced many health and safety issues. Tonometer systems which measure the pressure of the eye used to require a physical needle which would come in contact with the eye. This could be a potential cause of infection.

Most eye health professionals regularly sit down or complete repetitive motions when completing exams. These repetitive motions could put the professionals at risk of developing strain.

Mobile testing clinics may be more susceptible for safety issues because they require the medical staff to be housed in the vehicle. When in a vehicle, they may be at risk of being a part of a road accident. Otherwise, there is little concern about the health and safety of existing products.

2.2 Product Research

Various products that users use currently were evaluated to determine the advantages and disadvantages of each. These products were discovered by consulting expert advisors and doing online research.

2.2.1 Benchmarking – Benefits and Features of Existing Products

The most important features that existing products tend to have are related to the interface that they use to control the equipment, how comprehensive they are able to test, and the portability of the equipment. Equipment should generally be operated by a professional that is certified to deliver the results of the equipment.

Takeaways

- Most of the equipment that is able to make multiple types of measurements are larger
- Equipment with built-in digital interfaces are all-in-one devices
- Single function devices often require external screens or have simple functionality
- Analog equipment or equipment that have a more simple interface tends to be larger

• Devices that use smartphones are more compact

Benefits

TABLE: Benchmarked Product Benefits							
							
1	2	3	4	5	6	7	8
Essilor OST 100- OST 150	Eyenetra Smartphone Autorefractor	PlenOptika QuickSee	PSL Classic Portable Slit Lamp	Keeler TonoCare Non-Contact Tonometer	Visio Smart	EyeQue Insight	Wave Analyzer Medica 700+
Benefits							
Manual Operation All-in-One self containted kit Comfortable adjustment features	Portable Simple interface Fast operation Good compatibility	Portable Durable Accurate and proven measurements	Rugged design Portable formfactor Customizable	Easy to use Portable and durable Reduces risk of damage and infection to eye	Intuitive digital interface Simple integrated exporting functionality	Wide variety of measurement metrics Compatible with wide variety of devices Comfortable lightweight design	All in one screening solution Adjustable digital screen

Take aways

TABLE 2.2.1 Top Benefits of Benchmarked Products	
1	All in one solution
2	Large digital interface
3	Portablility
4	Durable
5	Comfortable

Table 3 – Benefits Benchmarking

2.2.2 *Benchmarking – Functionality of Existing Products*

Features

TABLE: Benchmarked Product Features/Functionality								
								
	1	2	3	4	5	6	7	8
	Essilor OST 100- OST 150	Eyenetra Smartphone Autorefractor	PlenOptika QuickSee	PSL Classic Portable Slit Lamp	Keeler TonoCare Non-Contact Tonometer	Visio Smart	EyeQue Insight	Wave Analyzer Medica 700+
Features								
Refraction	Yes, Manual	Yes	Yes	No	No		Yes	Yes
Eye Pressure	Yes	No	No	No	Yes		No	Yes
Retina Exam	Yes	No	No	Yes	No		No	Yes
Exporting Functionality		Digital	Digital	Digital	Yes	Digital	Digital	Yes
Level of Portability	Furniture	Yes	Yes, Durable	Yes, Durable	Slightly	No	Yes	No
Ergonomics	Good Adjustment			Slight Adjustment	N/A	Slight Adjustment		Slight Adjustment
Material	steel powder coated and plastic	Plastic	Plastic and Rubber	Plastic and Rubber	Plastic	Plastic	Plastic and Foam	Plastic
Manufacturing	Bending, Welding, Moulding	Injection Molded	Injection Molded	Injection Molded	Injection Molded	Injection Molded	Injection Molded	Injection Molded
Smartphone Required	No	Yes	No	No	No	No	Yes	No
Self Use	No	Yes	No	No	No	No	Yes	No
Size	Large	Small	Small	Medium	Medium	Medium Large	Small	Medium Large

Take aways

TABLE 2.2.2 Top Features of Benchmarked Products	
1	Refraction Measurements
2	Portability
3	Level of Adjustment
4	Material
5	Self Use
6	Ergonomics

Table 4 – Features Benchmarking

Figure 3 – Product Benchmarking

The main function the equipment needs to be able to do is to take refractive measurements which is required to prescribe glasses. However, this test is slightly misleading because not all of the devices that were benchmarked are intended to be comprehensive solutions and did not have this feature. However, devices that were able to adjust and had good ergonomics stood out among the others. The size of the device was also a major factor that differentiated certain devices from others.

2.2.3 Benchmarking – Aesthetics and Semantic Profile of Existing Products

Existing products used a very basic and soft look on products. Products were designed to have a very generic medical look with focus placed firmly on functionality.

2.2.4 Benchmarking – Materials and Manufacturing of Existing Products

Most of the existing products are housed in plastic. They often use injection moulded for the outer shell. However, larger parts are not economical to injection mould. For larger parts and parts that need more rigidity, metal like steel are used. Most of the devices also have an exterior paint finish to help blend the polymers with the metals in order to form a cohesive design aesthetic.

TABLE:Styling and Aesthetics in Eye Examination Equipment								
								
Overall Form (categories below reflect type of product selected)	Essilor OST 100- OST 150	Eyenetra Smartphone Autorefractor	PlenOptika QuickSee	PSL Classic Portable Slit Lamp	Keeler TonoCare Non-Contact Tonometer	Visio Smart	EyeQue Insight	Wave Analyzer Medica 700+
Shape *Geometric* Rectilinear, Ellipsoid, Cylindrical etc)	Rectagular	Elongated Oval	Rectangular	Rounded	Rectangular with Rounds	Cylinder	Rectangular	Spherical
Form	Industrial	Consumer Electronics	Futuristic Industrial	Dual Tone	Dual Tone	Medical	Consumer Electronics	Futuristic Medical
Accents			Orange accents	Blue accents	Blue accents	Side Holes	Mesh pattern of holes	Slots perpendicular to cyl. axis
Balance (symmetry etc))		left and right	left and right	left and right	left and right	left and right	left and right	Left and right

Table 5 – Styling Benchmarking

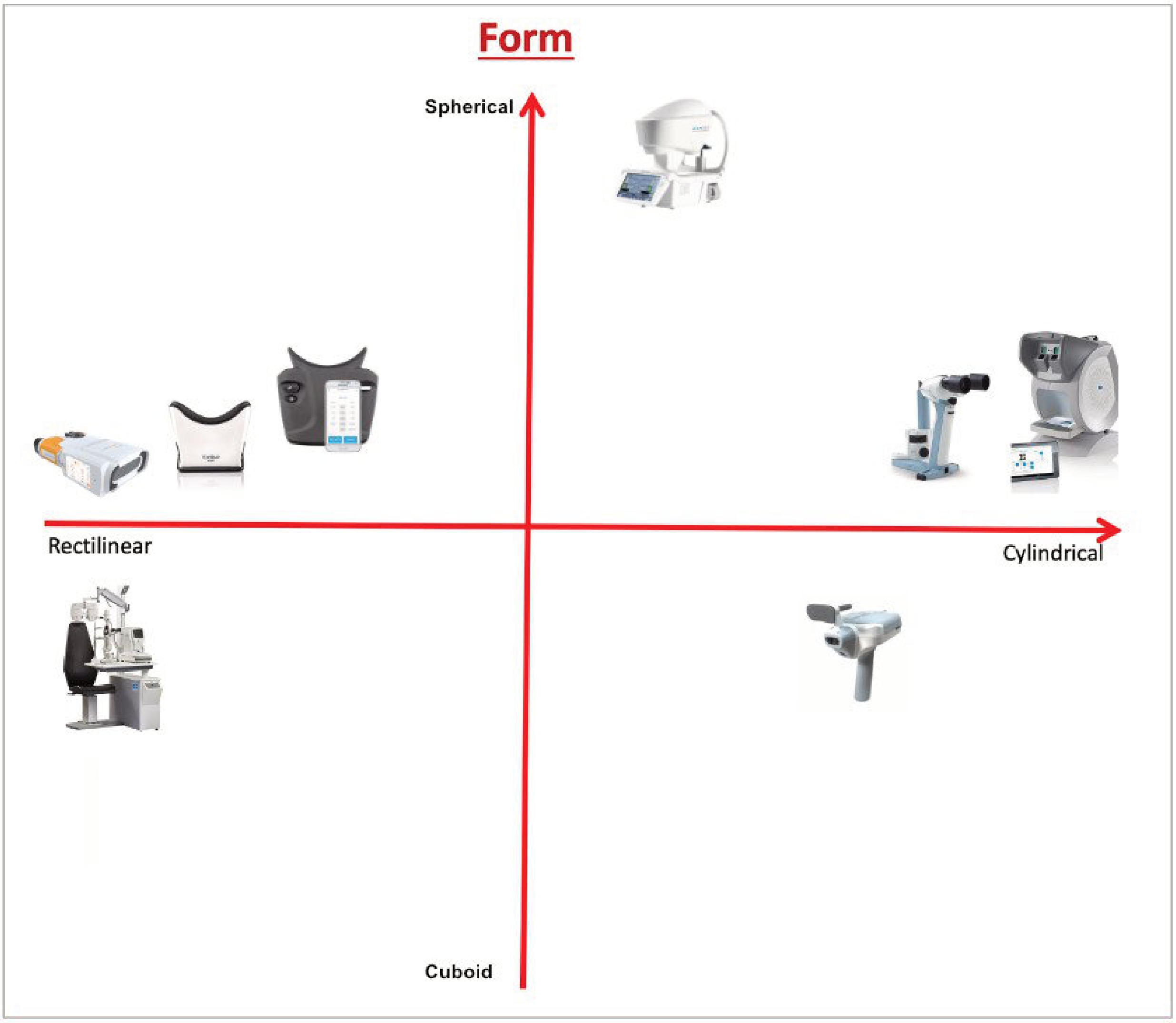


Figure 4 – Form Benchmarking

Some of the smaller eye-testing equipment intended for end consumers also use foam around the eyepiece. This is quite similar to the design of virtual reality devices. These foams tend to be expanded polymers which are then adhered into place. Additional rubber materials could also be applied to add to the texture and feel of the product.

Other materials that are used in some of the devices include a durable leather-like material such as vinyl for the chair. For the devices with touch interfaces, it is possible that glass or clear plastic surfaces.

Most of the materials are not listed on the manufacturer's website and is not easily accessible given the small market so this analysis was made on observing similar products and their manufacturing processes as well as the images that are featured on the website.

The use of mainly plastics means that a lot of these products will be long lasting and durable. Polymers are well known for the flexibility and ability to withstand impact while being lightweight. These properties are ideal for creating compact products that will be used by many different people and for use by medical professionals who travel. The foam padding that is around the eyepiece will improve the comfort and ergonomics of the testing equipment because the foam padding can deform to the shape of a face and will create a more inviting texture against the surface of the skin.

2.2.5 Benchmarking – Sustainability of Existing Products

Existing optometry equipment does not not seem to have a strong focus on sustainability which is understandable given the relatively low volume sales of medical products more generally. The use of metals makes recycling old equipment easier. Injection moulded housings also mean that products require fewer parts are lighter because of the use of plastics.

2.3 Summary of Chapter 2

Existing products often boast of portability, digital interfaces, and being multifunctional. The advancements allow eye testing equipment to be adapted into existing structures more easily. In the past, eye exam equipment needed to be mounted to equipment arms or placed on surfaces specifically designed for housing exam equipment. With all-in-one solutions, the entire setup of an optometry office could be changed to give more flexibility to the interior design as opposed to designing the layout around the bulky equipment.

The aesthetic language of the equipment is also equally flexible in its possible applications. All of the different products that were compared were generally very subtle and have generally the same design language. The equipment compared is generally very utilitarian and also not very dynamic.

The materials and manufacturing techniques were also relatively similar among all of the products compared. The polymers that were used are well known for being durable and versatile. Similar polymers are likely used for other medical equipment and consumer appliances.

The general aesthetic design and materials lend itself to be used in a wide variety of interiors and environments. The focus on functionality, technical innovation, and user interface means that the technology could perhaps be transferred to a different housing while still maintaining its properties as eye examination equipment. The only concerns are with the ability of certain dimensions to adjust to improve ergonomics and the foam materials which improve comfort.

CHAPTER 3 - Analysis
Evaluating Research

3.1 Analysis – Needs

The analysis of problems looks to evaluate the pain points and to dig deeper into the user research. The previous evaluation of the products looked at what the product offered physically and what they was able to do for the user. However, the aim of the product is to fulfill the user's concerns and the users needs even before they know they have that need. In order to understand these less apparent needs, some analysis into users' character is required.

3.1.1 Needs / Benefits Not Met by Current Products

Existing products mostly are able to complete the examinations at a fundamental level but lack a personality. They are very generic and they do not suggest the function that they perform. They also are not able to distinguish themselves from other products nor do they coordinate particularly well with the environments that they are placed in. The lack of character makes the product less inviting to use and more forgettable.

On a more functional level, though compared products are able to complete many functions at once, they are often not able to adjust to the height of the user. Other portable products can simply be placed on the user but they are not able to be mounted in case multiple users need to be tested over an extended period of time. The portable solutions do not appear like they are designed to work in clinics that handle a large volume of users.

3.1.2 Latent Needs

- To have access to a reliable eye care facility (provides a sense of safety and security in case there is a sudden need for eye care) (safety)
- To receive glasses in a timely manner (occupied the mind when there is attendance to an appointment is expected)(social)
- To be able to afford glasses (being able to afford something that is very important and how easily one is able to afford that) (safety)

3.2 Analysis – Usability

Understanding the user’s latent and immediate needs, the workflow, and the thought process of that work flow needs to be first understood. To make that assessment, a user map and a journey map will be made.

Pain points of getting an eye exam stem from organizing a time and a method to reach the exam center. Users are expected to experience frustration with organizing a time to

3.1.3 Categorization of Needs

Immediate Needs	• To be able to see properly and play a more effective role in society by participation in productive work. • To be able to see clearly • Quick screening • Highly accurate readings • Remove negative connotations with visiting eye health professionals
Latent Needs	• To have access to a reliable eye care facility • To receive glasses in a timely manner • To be able to afford glasses
Wishes and Wants	• Have stylish glasses • Have a variety of glasses to choose from • Fast and easy system to acquire glasses • Receive high quality glasses • Receive durable and long lasting glasses • Not greatly disturb work schedule in making time to do eye exams

Table 6 – Categorization of Needs

schedule an appointment because they need to call ahead and make time for it. Then they must either take time out of their working hours or take time away from their weekend in order to attend the appointment.

Once users receive an appointment, they will also have to get to the appointment on time. Many factors such as traffic and car accidents can prevent this from happening. There can be a lot of frustration with how strict the timing of appointments is enforced. Arriving late can result in late fees can really diminish how a user perceives the experience.

	Planning	Preparation	Task 1	Task 2	Task 3	Goal	Finished
User Goals	Deciding to get new glasses after vision gets worse	Make an appointment with the optometrist	Go to the optometrist to get eyes checked	Bring prescription to the optician and eyeglasses vendor	Choose glasses and place the order	Pick up the glasses and get them fitted	Bring home the glasses and use them
User Actions	Understand that there is a problem with sight	Look online to find a nearby eye doctor, call to make an appointment, and schedule the appointment.	Take transit to get the optometrist's office, sign in, register, and attend the appointment.	Take the prescription from the optometrist to a eyeglasses vender which is usually connected to the office.	Try on different glasses, compare the styles, pick a pair of glasses, and order them.	Go home, wait for the glasses to arrive, and go back to the glasses store. Try on the new glasses, and get them adjusted by the optician.	Try out the new glasses in the real world and show them off to others.
User Thoughts	I wonder why I don't seem to able to see certain things.	I will have to try to find to fit this appointment in my schedule and find some money to pay for this.	I hope I am not late and I also hope that the wait is not too long.	I can't wait to buy new glasses but I also hope that they won't be expensive.	I wonder what my family and friends of these different styles.	I wonder when my glasses will finally arrive so I don't have to wear these old pairs anymore.	I am really proud of my choice!
User Feelings	Worried about how to get this fixed.	Anxious about fitting this into my busy schedule.	Rushed and nervous to get to the appointment on time and meeting the optometrist.	I am super excited to get new glasses.	I am curious about all these different styles!	I am feeling impatient about waiting for these glasses and I am upset I can't use them right away.	I am glad that I finally have my new glasses.

Table 7 – Journey Mapping

Users are also not able to immediately get their glasses after they have finished their exam and have chosen their glasses. They may need to book a followup appointment which could create more scheduling conflicts.

Users often feel pleasure when they are done with their eye exam and are able to choose new glasses. Seeing the different styles, trying them on, and shopping for glasses can promote a sense of novelty for the user inspiring delight.

The main points of negative experience are with organizing and appointment and allocated the required amount of time for that appointment. In addition to that, scheduling follow-up appointments was also a point of stress but usually those appointments are a bit more flexible and as a result are less impactful than the initial appointment. Though the eye examination process does have positive emotions associated with it, it is not because the process is appealing but instead because the activities after it are appealing. Because this part of the process is still quite neutral, it may be possible to improve this aspect of the experience as well.

3.2.2 User Experience

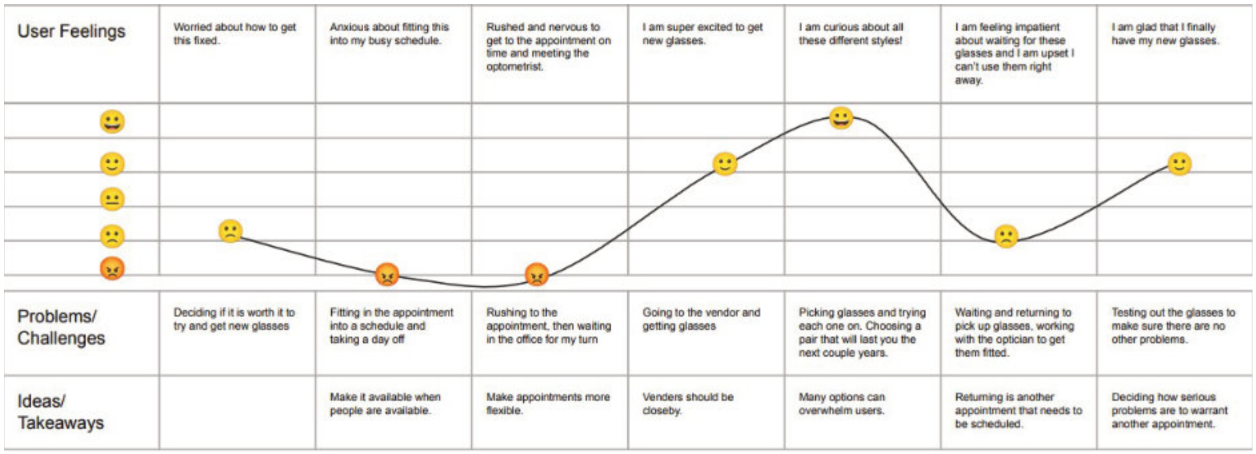


Figure 5 – User Experience Map

3.3 Analysis – Human Factors

For the purposes of developing a tele-optometry clinic that can be comfortably and safely used by a wide variety of users is of great importance. Addressing concerns with human factors will also allow for more intuitive user interactions. Given that there are many existing in-person optometry tools and also tele-optometry equipment, there are many existing starting points. However, many tools are not able to be combined into a seamless and intuitive experience. To achieve success in creating a comfortable and safe product, an ergonomic study was completed. Given the wide variety of users that could be using this product, completing this study would allow this solution to be more inclusive. The extended period of time that remote optometrists would have to work at the workstation also means that there can be health and safety risks of strain. The objective of this study is to both be inclusive and promote healthy working by evaluating the ideal ergonomic properties for a tele-optometry clinic.

Before a model for the design could be completed. The different position of the equipment and control systems affect how the model will be made. To determine some of those dimensions, some research had to be completed.

3.3.1 Product Schematic – Configuration Diagram

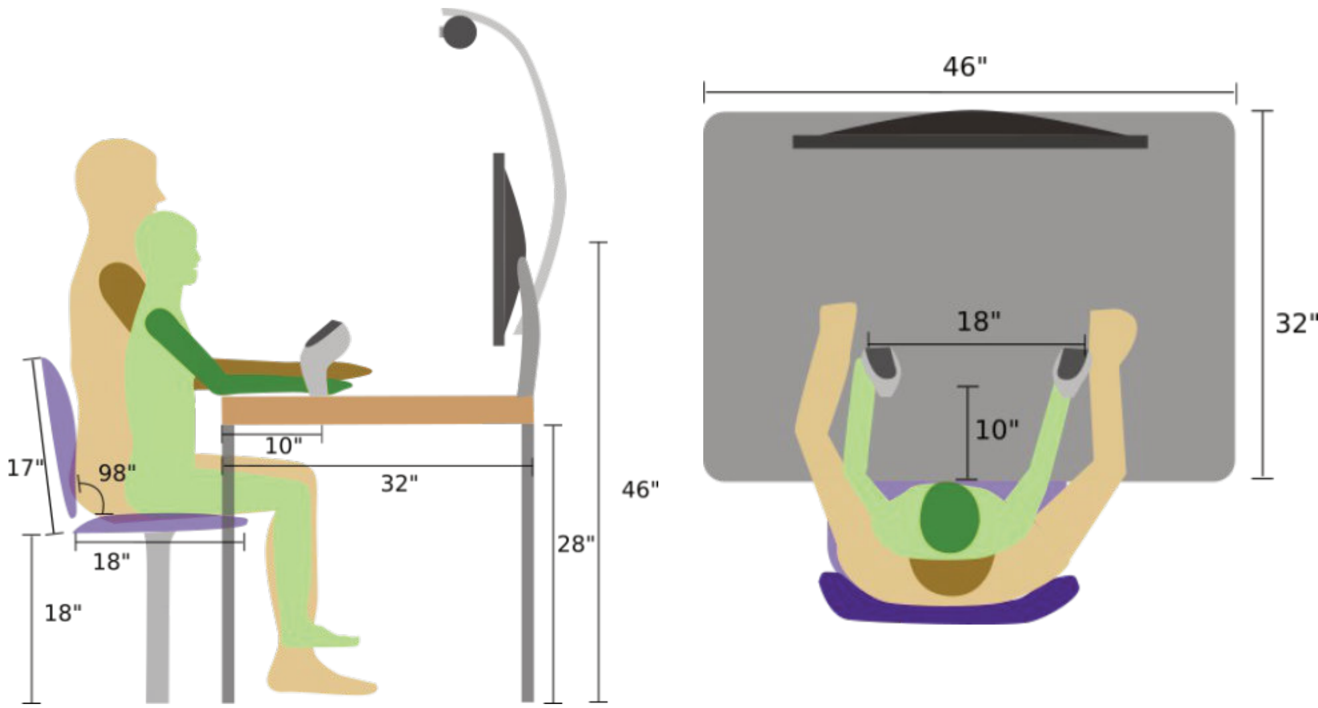


Figure 6 – Operator Configuration Diagram of Previous Design

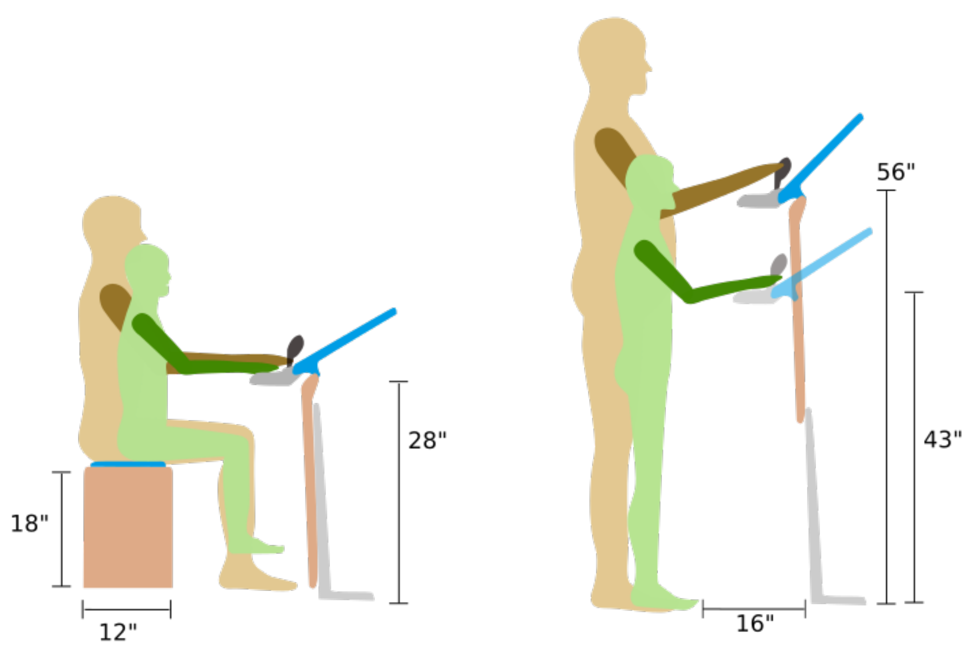


Figure 7 – Operator Configuration Diagram of Current Design

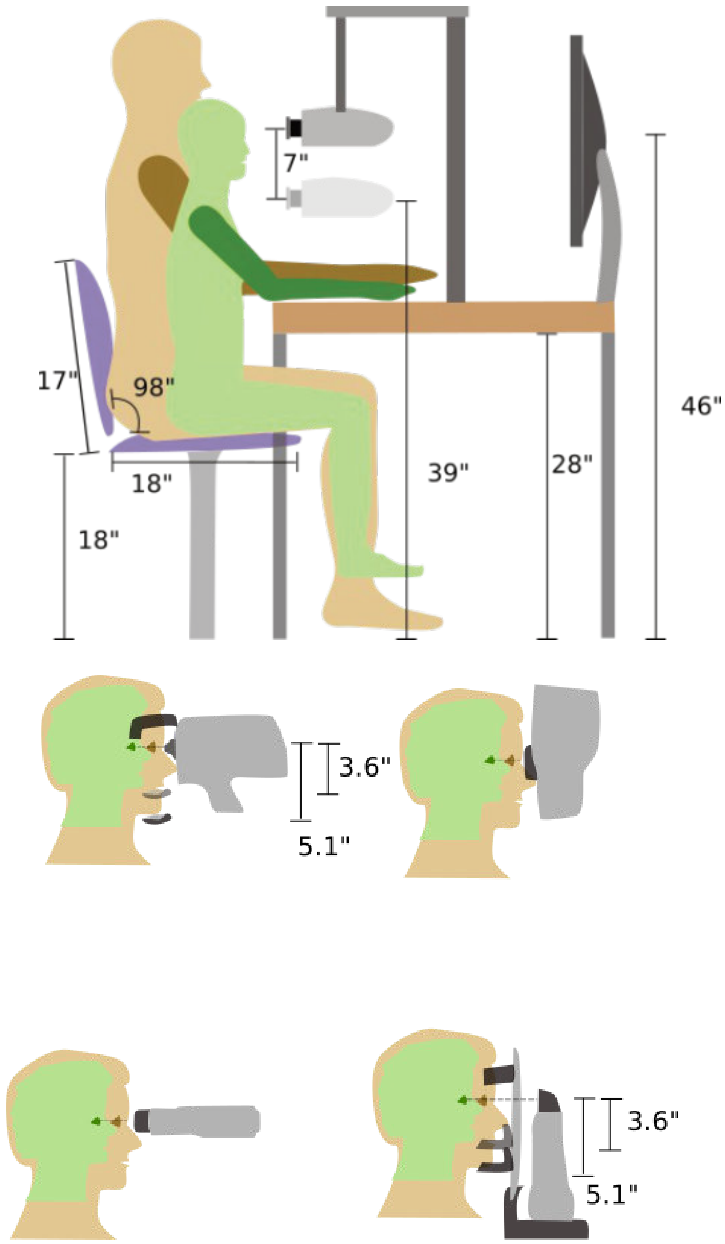


Figure 8 – User Configuration Diagram

To inform the initial dimensions various sources were found. Many of the dimensions were informed by Tilley and Dreyfuss (2002) and National Aeronautics and Space Administration (NASA, n.d.) which provided sources of percentile dimensions of the body. These dimensions give a rough estimate to the size of certain key parts of a design such as seat height and seat depth which can be derived from the dimensions of the foot to the knee and the knee to the buttocks. These dimensions often differ from products in reality and after consulting with more experienced professionals in the field, it was apparent that completing benchmarking of standardized product sizes was necessary. Various online sources listing some of the common industry dimensions of workstations and work areas. They were found to further inform the dimensions to match existing products on the market. (Green, 2022) (M, 2020)

3.3.2 Ergonomic – 1:1 Human Scale Study

Initial dimensions of key components were first determined by reviewing literature and making estimates as to what dimensions would be ideal. Once these dimensions were decided upon, they were applied to the structure of the model which focused on only the most important

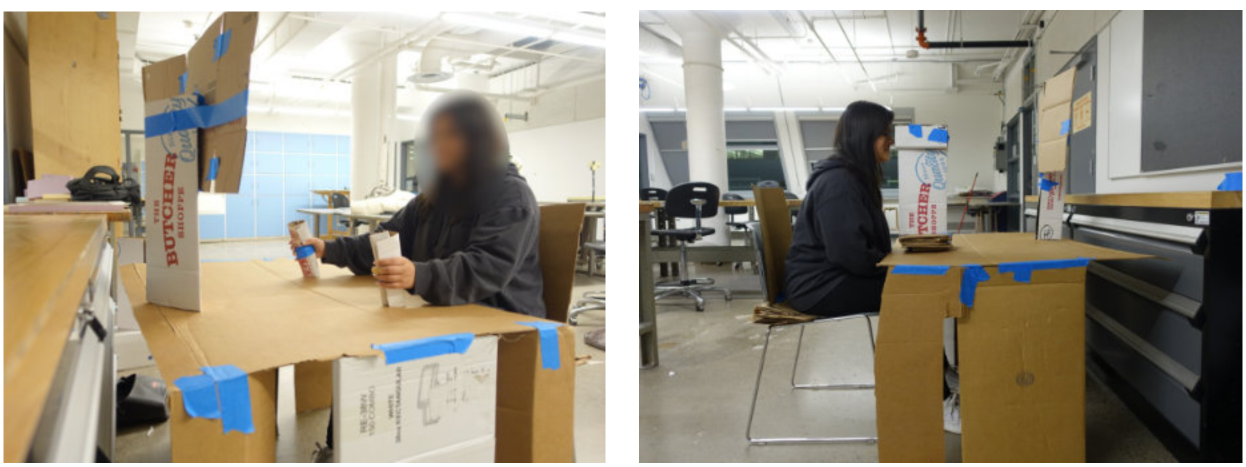


Figure 9&10 – 1:1 Model 5th Percentile

Figure 11&12 – 1:1 Model 95th Percentile

ergonomic metrics. In reality, many of the dimensions that were originally derived were not entirely accurate to the real life reference user.

The 5th percentile female found that the eye level for the eyepiece was too short for her. The preferred height was around 33”. The original measurement was taken from the seated eye height (Tilley & Dreyfuss, 2002) but it was discovered that it was more comfortable to lean forward. The height of the bottom of the table surface was perceived to be too low for comfort but upon sitting in the chair, there was no real issue with the height. They did remark that they thought it would be likely that the 95th percentile male would have some issues with the table height. Even though this critical dimension did not pose a problem, it may be wise to modify the dimension slightly to allow for more room.

The 95th percentile male also reported some issues with the eye level. The eye level was too tall for him and needed to be brought down. The table height did not pose a problem for the 95th percentile male even though the user was reluctant about whether they would fit in the chair. Though seating comfort is not affected by the table height, the ease of being seated was partially affected.

Given great variation of eye heights between different users and after benchmarking existing products, it was determined that an adjustable eye height would be ideal. The chosen eye height was originally adjustable up to 14” apart, but after the analysis with the users it was determined that that was not necessary. When leaning forward and depending on the seating position, users found it more comfortable to meet the eye level of the equipment if it was lower. However, with adjustable equipment, the necessity is just that it meets the range of dimensions that are required by the users. If the adjustable equipment is able to accommodate even more users, it will not negatively affect the existing users as it will still be able to serve them. For the purposes of the study, however, the focus will remain on the critical dimensions. The tested range of eyepiece height is 39” to 46” giving a minimum adjustment range of 7”.

Neither of the users had issues with the seat height and with the seat depth. Given that they spent most of the time in an attentive position, the backrest was not used very frequently but did not provide discomfort either. The seating position which was taken from rough estimations of NASA (n.d.) dimensions of percentile figures was not an issue.

Regarding the usage of the equipment and the viewing angle of the display, there were no major problems either. Viewing angles of the display were set at the eye height of a 50th percentile male. Given the general smaller stature of females and how large displays are generally mounted at eye or higher, the 50th percentile male dimension was chosen. Both the 5th percentile female and the 95th percentile male did not report any strain from viewing the display and the display’s size was able to match their line of vision.

The position of the controls for the equipment was roughly chosen to be around the distance from the elbow to the hand of a 5th percentile woman. The dimensions of a 5th percentile woman were chosen because a 5th percentile woman would have trouble reaching a further distance but a larger person would not have that same difficulty. The measurements in reality were a far bit closer as users had a gap between their body and the table. Users could also spread their elbows out further if they felt like there was too little room between the controls and themselves. In the end, it was concluded that closer controls would be preferable to further controls. The general position of the controls would ideally be roughly within an 11” radius of the center of the edge of the workbench. This radius marks the range of motion for items that require frequent interaction.

Using a mixture of dimensions from benchmarking and dimensions from human measurements, a greater understanding of the ergonomics of a tele-optometry clinic can be determined. Once those findings were compared with real users and their insights were collected, a more comprehensive picture of how the human factors would impact the function was made.

3.4 Analysis – Aesthetics & Semantic Profile

Existing plain white medical facilities tend to lack personality and do not inspire a sense of hospitality to the user. Existing telehealth services also try to take advantage of the fact that there is little space that is required to operate that facility. However, using up space to create a

Figure 13 – Aesthetic & Semantic Profile

positive environment can create a more enjoyable environment for users. By defying the cramped eye exam room expectations, users may be more motivated to attend appointments and motivate others to also attend.

Introducing a more precise and function aesthetic may also make the users feel less alienated from the process of receiving eye care services. These types of honest and visible indicators of functionality will make the equipment seem less daunting and complex.

3.5 Analysis – Sustainability: Safety, Health and Environment

With existing philanthropic solutions currently being available, there is always a risk that funding will stop due to the lack of a financial incentive. (Advisor 2, personal communication, 25 October, 2022) To create an effective solution, it must also have a sustainable business proposition. Using telehealth, the relatively small demand of individual remote small lower income communities can be easily accumulated to form a substantial demand. By combining this demand, it becomes a more lucrative opportunity to capitalize on this demand and provide services to these communities.

Telehealth also provides many advantages to improving the sustainability of distributing glasses. It minimizes commutes for both health providers and customers by connecting both parties using the internet. On-site manufacturing also simplifies supply chains for glasses as it is able to reduce the number of items that need to be regularly stocked at a vendor.

3.6 Analysis – Innovation Opportunity

Though existing telehealth services and facilities already exist, there are few that are able to accomplish many different roles. New facilities have the potential to push the limits on multiple different types of emerging technologies like 3D printer, CNC cutting, and the delivery of telehealth. In addition to the technical opportunities, there is a great possibility to expand in creating an interactive experience in a way that can streamline the process of getting new glasses. Combining technical and conceptual improvements of existing suites of products give opportunities to innovate.

3.6.1 Needs Analysis Diagram

The root problem for users based on the research that was conducted is that existing means of gaining access to vision care is too complicated. It seems to lack a simple method of

Assessment Questions	Synthesis
What type of trends do you observe about the needs of the users?	The needs of the user often include difficulty understanding the services that are provided to them and difficulty understanding the details of eye health. Once those are understood, finding and scheduling eye health appointment is the next great challenge. (Advisor 2, personal communication, 25 October, 2022)
What are your users' most urgent needs?	Users need to be able to see and need to be able to know if their eyes are in good health. Once the health of a person's eyes can be evaluated, getting glasses to them is usually less difficult. (Advisor 1, personal communication, 14 October, 2022)
What are some of the main challenges with existing efforts?	Existing efforts have difficulty with reaching remote communities as they usually are not able to provide a return on investment. Accessing these communities may be possible with the help of donations but donations come and go and are often not sustainable. (Advisor 2, personal communication, 25 October, 2022)
What are not as much of a priority for users?	Frame style and the cost of the frames seem to be less of an issue because many users are able to use their old frames. Other users are able to buy less expensive brands of frames as they don't typically care as much about the style or brand name of frames. As long as the frames are high quality and last a long time. (Advisor 1, personal communication, 14 October, 2022)

Table 7 – Needs Analysis

getting started, which may frighten first-time customers. From a provider’s perspective, the lack of demand and incentive to provide services for these communities prevents significant investment to provide services to these communities.

Providing a simple frame and lens in a pair of glasseswill already address a significant portion of the needs of these users as they are not looking for high-end designs and state-of-the-art technologies in their glasses. Especially as it may be out of their price range.

3.6.2 Desirability, Feasibility & Viability

Current technology already has the means to make a concept with 3D printing and telehealth possible. With the rapid pace of innovation in telehealth solutions, satellite internet, and 3D printing, a better teleoptometry experience is possible. The rapid development of higher quality materials can also likely eventually be used in making frames more sturdy and environmentally friendly.

Potential challenges with this concept would be finding and organizing the workflow of the health provider. It may be costly to keep health professionals on call if demand for services are not consistent enough. Several years of testing this concept may be required before patterns of demand are observed. Understanding these patterns can better inform the amount of on-call health professionals needed at a given time.

The form factor and design of the finalized concept may currently not be optimized for manufacturing and transportation to remote communities. Modifications and redesigns for a more practical solution may be required during the execution of this concept. Potential solutions to executing a concept like this would be to use prefabricated structures or create an open-sourced design that can be constructed by individuals from within a community. Incentives for businesses to include a tele-optometry clinic in their place of business such as providing a cut of sales may also stimulate local economies, increase adoption of these services, and create an incentive to improve awareness of these services.

The potential to receive vision care and glasses extremely quickly and at an affordable price are desirable to individuals who need vision care based on the interviews and surveys that were conducted. Creating an experience that is fully guided and has a low barrier to entry will make this solution preferable to first time users.

3.7 Summary of Chapter 3 – Defining Design Brief

The end product of this project is to develop a solution to develop a product which helps users access eye care more easily within their existing circumstances. Additional concerns that the developed solution includes:

- Develop an affordable way of receiving glasses which streamlines existing manufacturing processing
- Allow for visits to get vision care to be more respectful of the users' time
- Ensure that the solution will still function in rural communities
- Only requiring one visit in order to accomplish most common tasks (such as receiving glasses
- To inspiring a calm and welcoming environment for users
- Include all the equipment for a comprehensive eye exam instead of having to be referred to another facility
- To offer a wide variety of differently sized products for users on different percentiles

CHAPTER 4 - Design Development

The process of exploring designs solutions is discussed in this chapter along with the documentation of the entire progression of the project. The main decision that took place early in the process was deciding on which methods of improving accessibility would be most suitable for the primary users. Before arriving upon the final decision, many maps discussing the different ideas were developed. Once a clearer direction was decided upon, features, the aesthetic language was developed.

4.1 Initial Ideation Development

4.1.1 Aesthetics Approach & Semantic Profile

In the beginning of the ideation process, most of the designs focused on making the eye care experience more portable. However, the possibility of a telehealth experience was then explored which was found to be a better fit for users based on the insights provided from the research. After a more defined direction was decided upon, inspiration for the aesthetic approach was made to guide the design details. In the inspiration board, several existing designs for eye care equipment are included as well as some more experimental media to push the design language to be more unique.

Figure 14 – Initial Inspiration Board

4.1.2 Mind Mapping

Before ideation began, several anticipated challenges were brainstormed and goals were then defined to determine the main challenges that a solution should tackle. This map was made as a part of the six part STEEPV analysis.

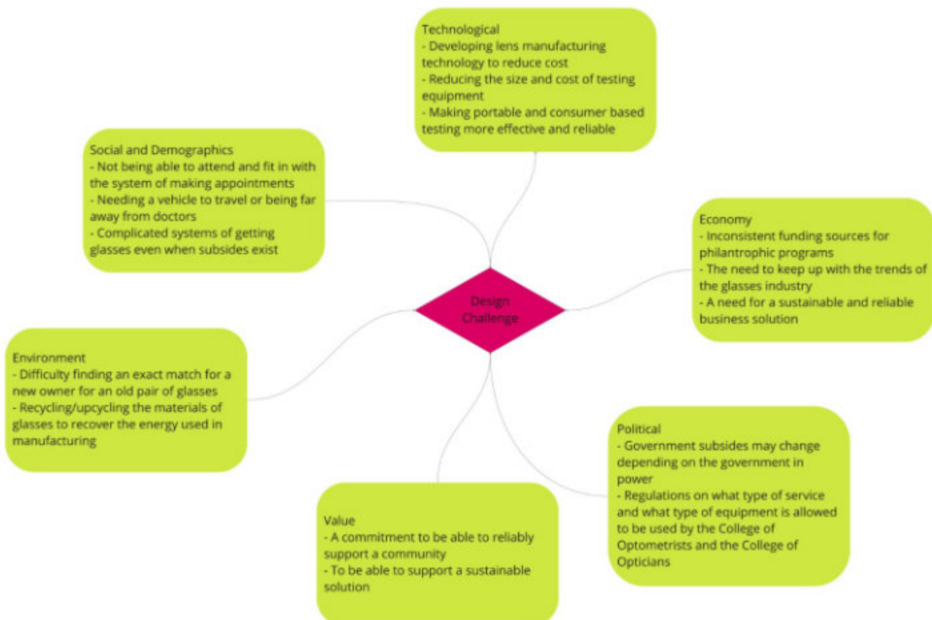


Figure 15 – Mapping of Anticipated Challenges

4.1.3 Ideation Sketches

Six different ideas to improve accessibility to users were first developed. Some of these ideas would be combined to form more grand concepts while others would be developed on their own. The main goal was to improve accessibility by making testing more mobile, making delivery of glasses more convenient, or by making glasses more affordable.

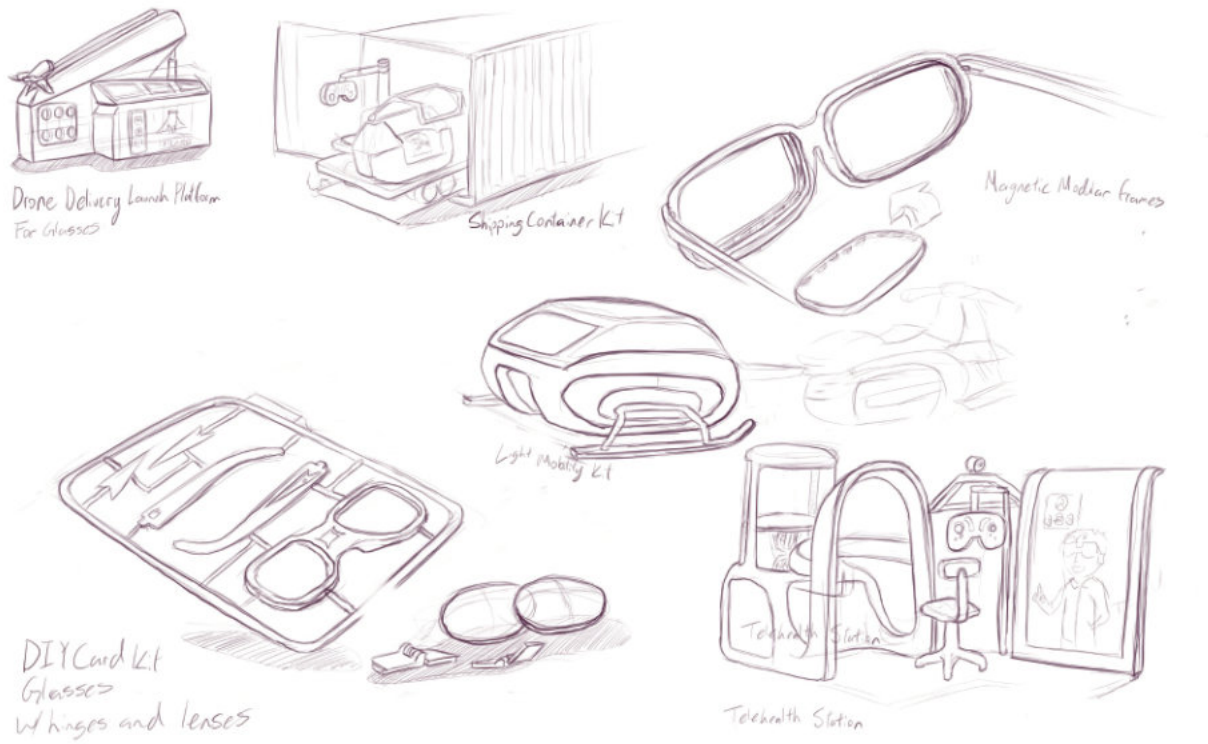


Figure 16 – Summary of Initial Ideas

4.2 Concept Exploration

During the process of developing the first round of ideation, the expert advisors were consulted and additional research was completed. This helped narrow down which concepts were the most promising and most feasible.

4.2.1 Concept One

The first direction that was decided upon was a tele-optometry/telehealth station that could be placed in a communal gathering area. This facility would have equipment that is remotely controlled by an eye health professional and have its own 3D printed glasses manufacturing facility.

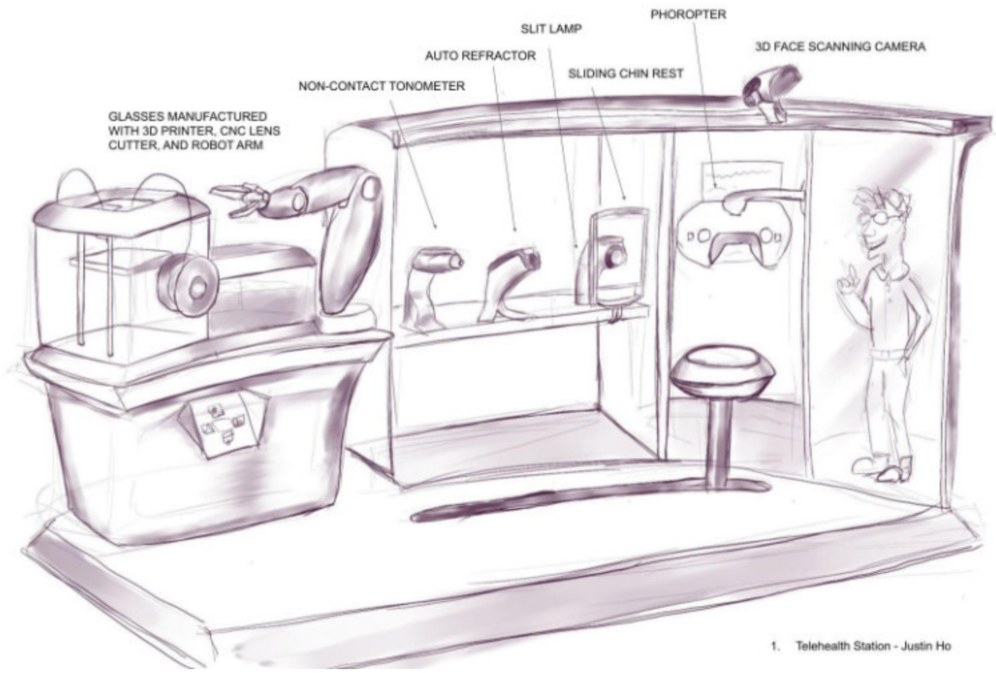


Figure 17 – Telehealth Station Refinement

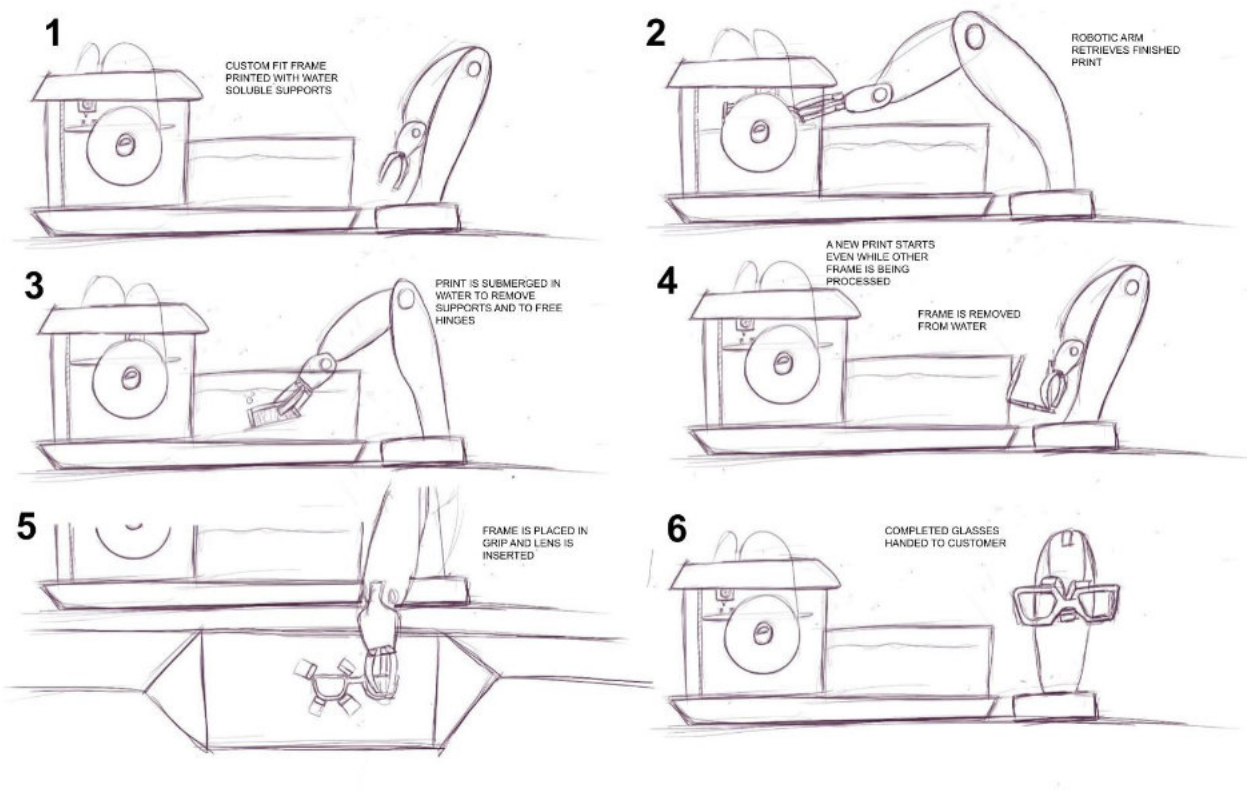


Figure 18 – Process of Manufacturing

4.2.2 Concept Two

The next concept that was further refined was a backpack which travelling eye health professionals could use to power and store their equipment. It would also store their provisions. It was intended to be used for those who travel to areas not easily accessible by car.

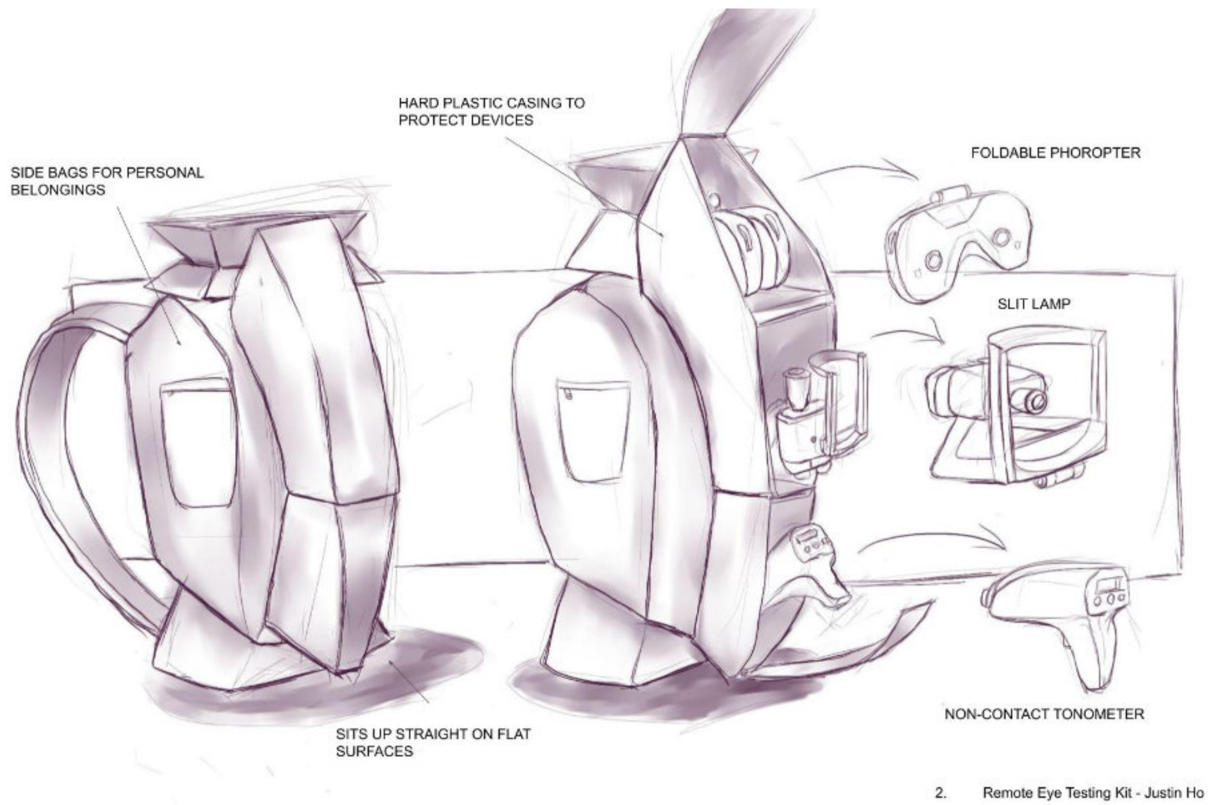


Figure 19 – Mobile Testing Kit

4.2.3 Concept Three

Expanding on existing offerings of mobile testing clinics, concept 3 focuses on making the mobile storefront more appealing and less cramped. It features a sleeping quarters for staff and is intended to be used for long road trips. It aims to provide a more premium experience to the lower income communities that it serves.

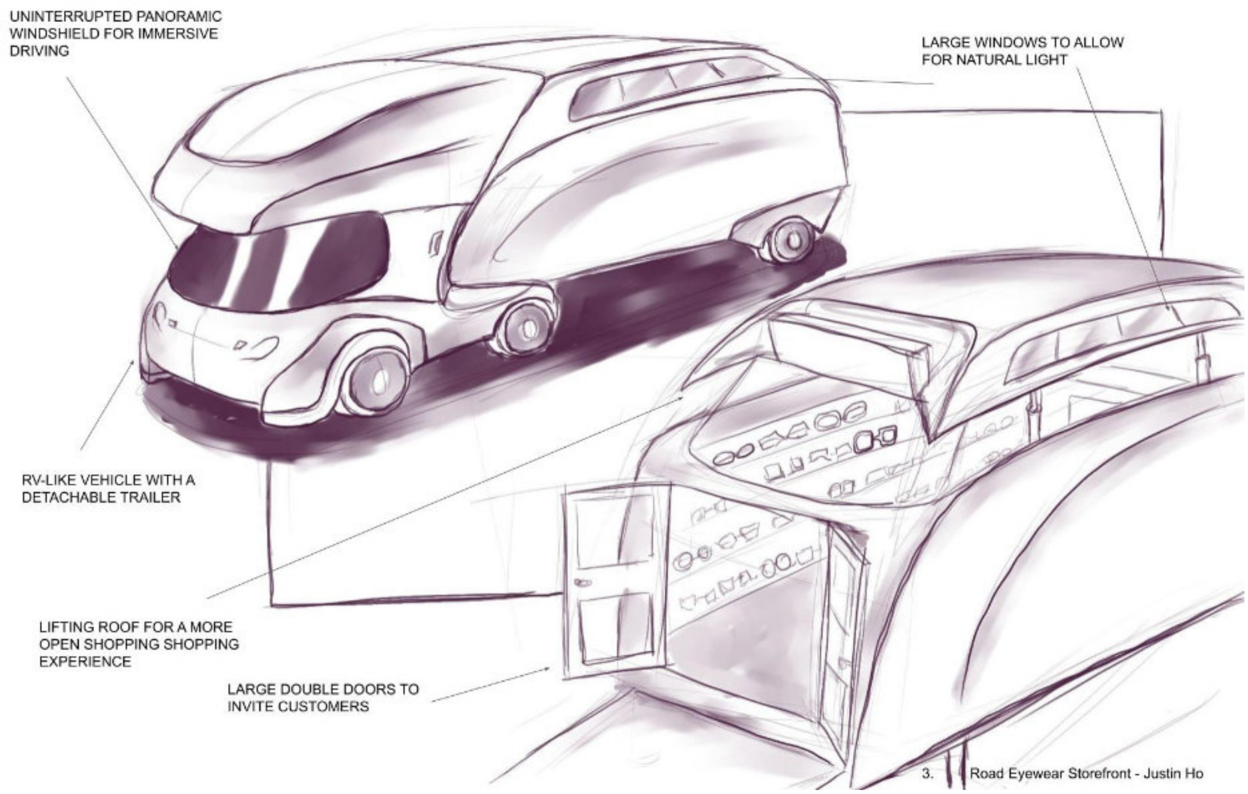


Figure 20 – Mobile Eye Center RV

4.3 Concept Strategy

With the previous concepts developed further, one of the obstacles that still stands is how realistic each concept is. To determine the scale of the design and the different parts that it will require to function, the major components of each of the designs are mapped out.

4.3.1 Concept Direction & Product Schematic One

The tele-optometry station now required a control booth for the health professional and the booth that the customer interacts with. The main equipment that was determined to be essential for a comprehensive eye exam based on consultations with advisors was a tonometer, slit lamp, auto-refractor, and a phoropter. In addition to the examination

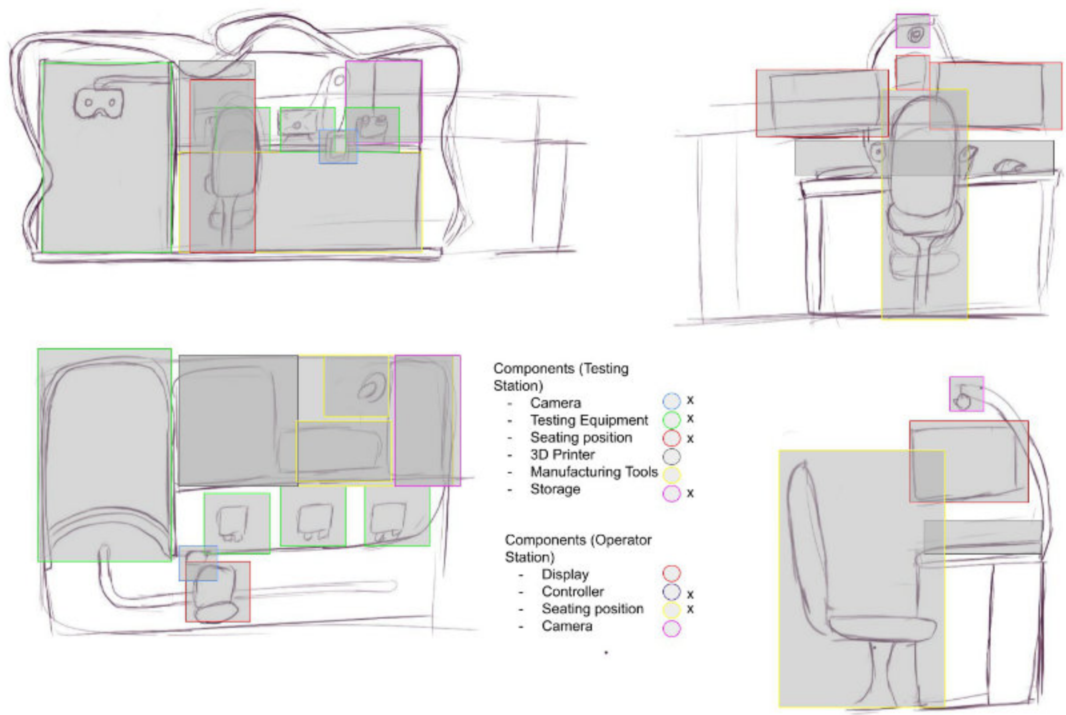


Figure 21 – Schematic Diagram Telehealth Station

equipment, displays, cameras, and the tools for manufacturing also need to be considered for the station to function.

4.3.2 Concept Direction & Product Schematic Two

The second concept direction had changed quite significantly to be more suitable for the snowy and vast environment of Northern Canada. Designed as a self-balancing trailer

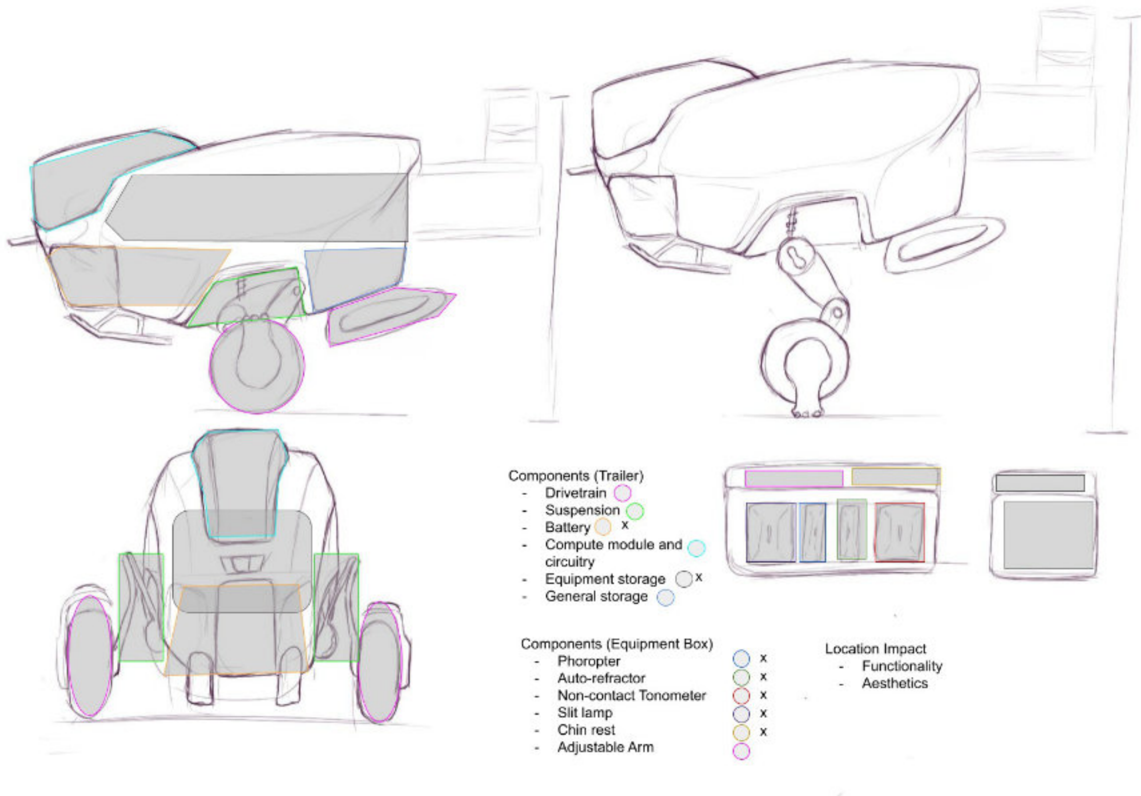


Figure 22 – Schematic Diagram Mobile Testings Station

that can travel many different terrains effectively, the testing station aims to be as versatile as possible. It features a crate that provides easy access to the previously mentioned testing equipment. It also has a motor and skis for traversing snowy terrain, batteries for charging equipment, and finally, wheels and a suspension system for paved surfaces.

4.4 Concept Refinement & Validation

This sub chapter discusses development and exploration of the concept direction as well as resolving different details.

4.4.1 *Design Refinement*

The design direction had now been established as a booth/station that is placed outside of a public building in a parking lot. This concept aims to improve sight lines and make a calmer and more peaceful environment. It also implements the use of satellite internet to ensure a reliable connection wherever it is located.

The design of the kiosk has also been developed further to allow for seated and standing postures. It has also been redesigned to look less utilitarian and more simplistic.

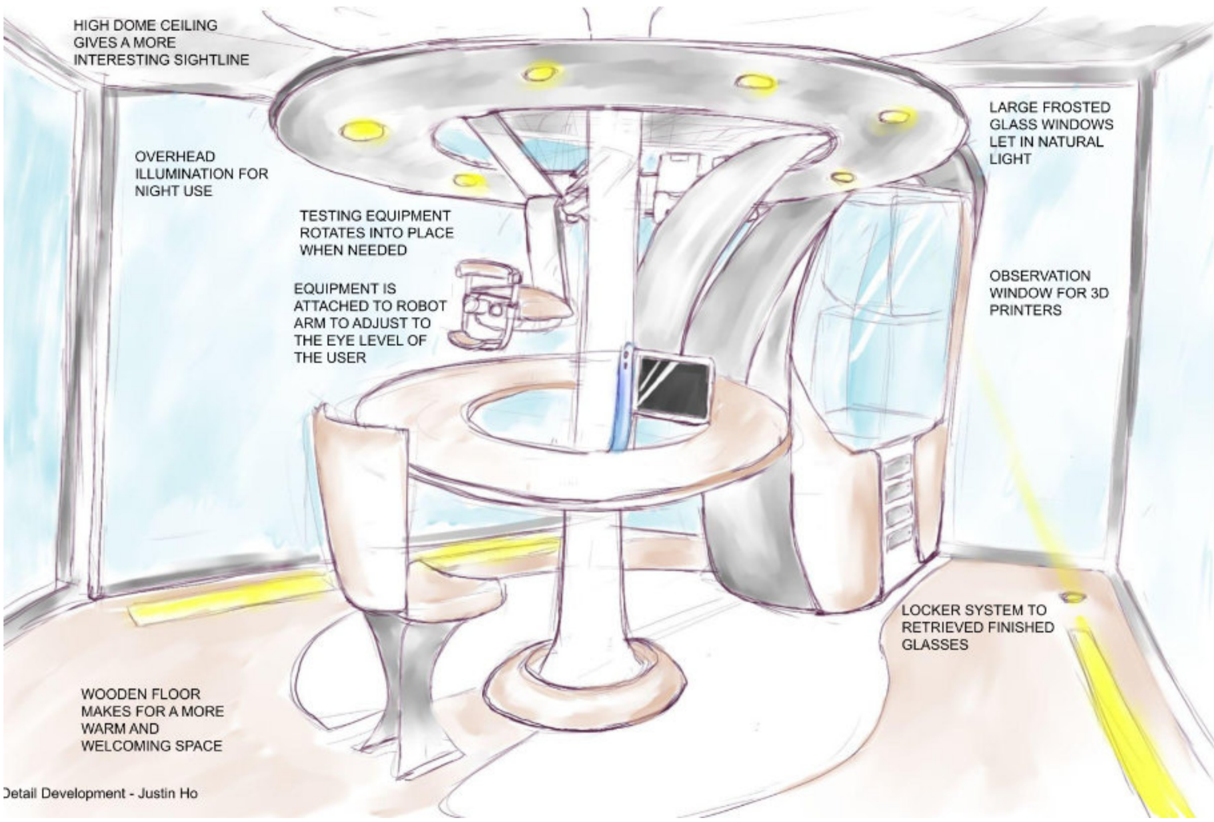


Figure 23 – Interior of Tele-optometry Station

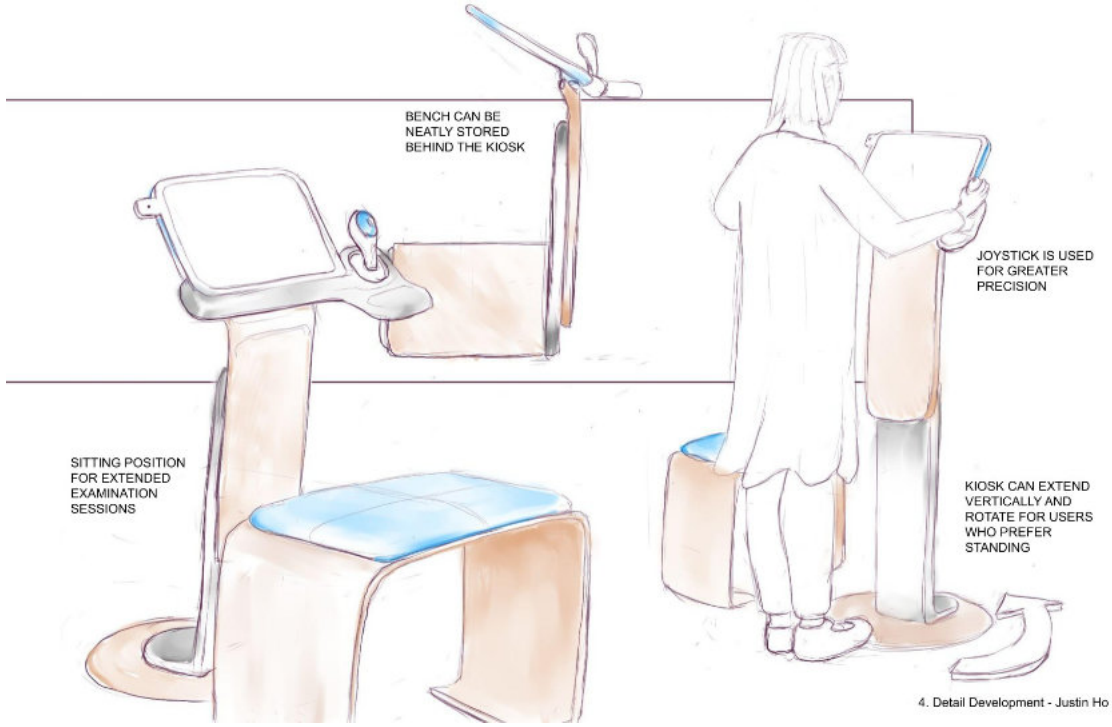


Figure 24 – Control Kiosk

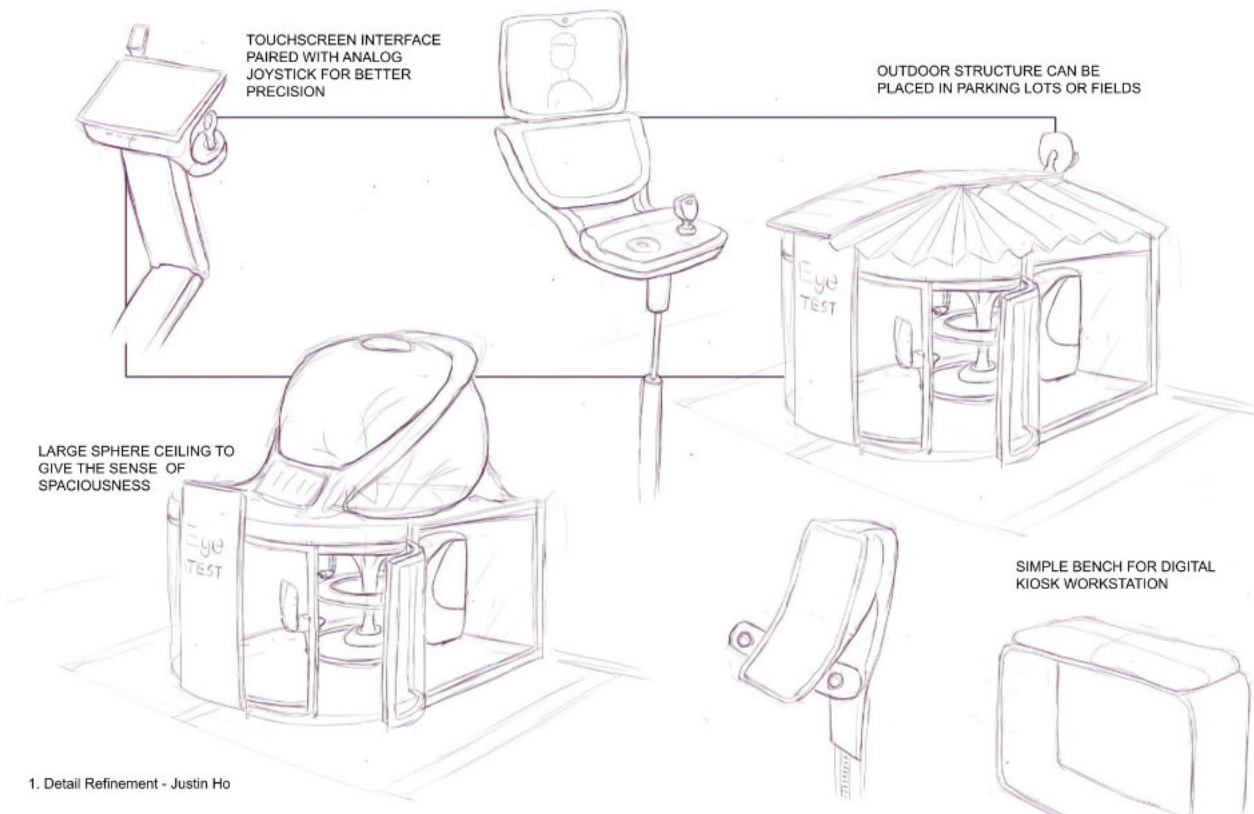


Figure 25 – Sketches of Concepts for Station and Kiosk

4.4.2 *Design Development*

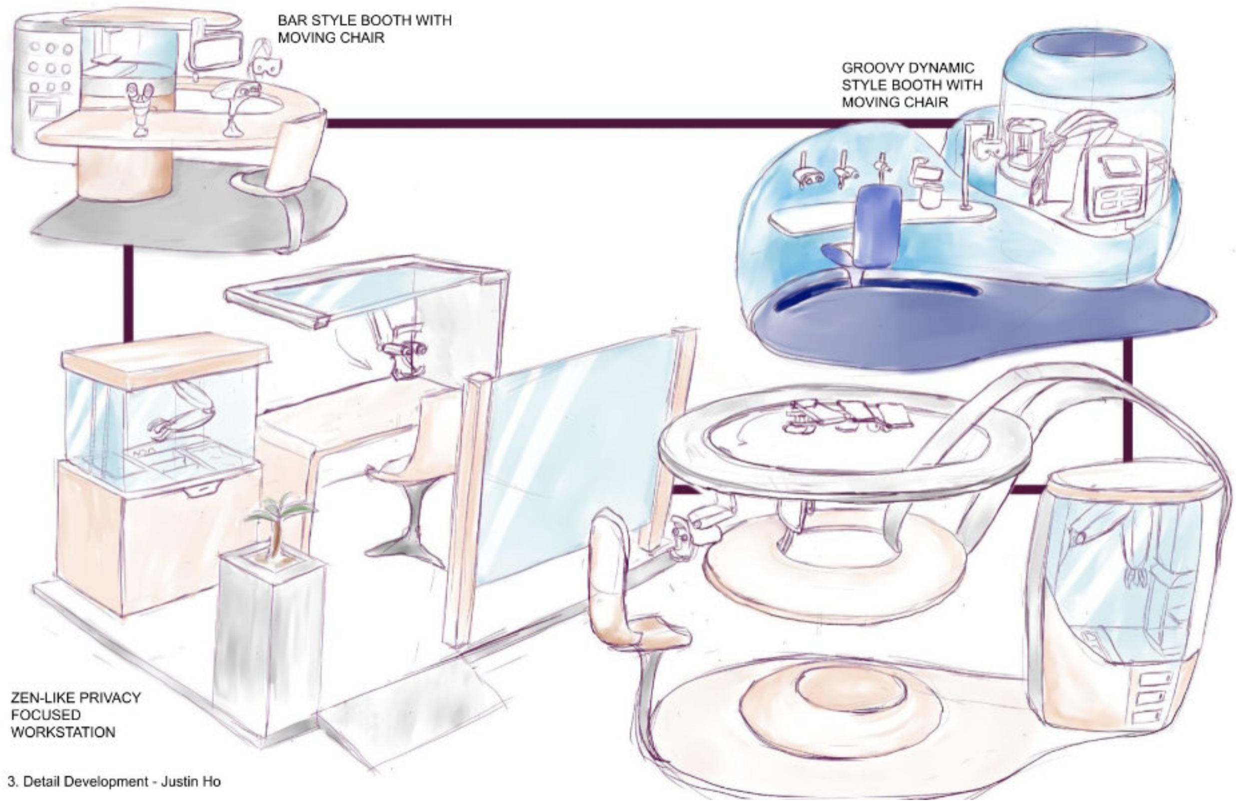


Figure 26 – Aesthetic Languages of Stations

Before arriving upon the final concepts, several different ideas were considered and different aesthetic languages were considered.

4.4.3 *Defined Product Schematic & Key Ergonomic*

Though most eye-testing equipment have variants that do not require a forehead rest or a chin rest, the ergonomics for variants that do have chin rests were evaluated. The general ergonomics of these new concepts were also updated as required.

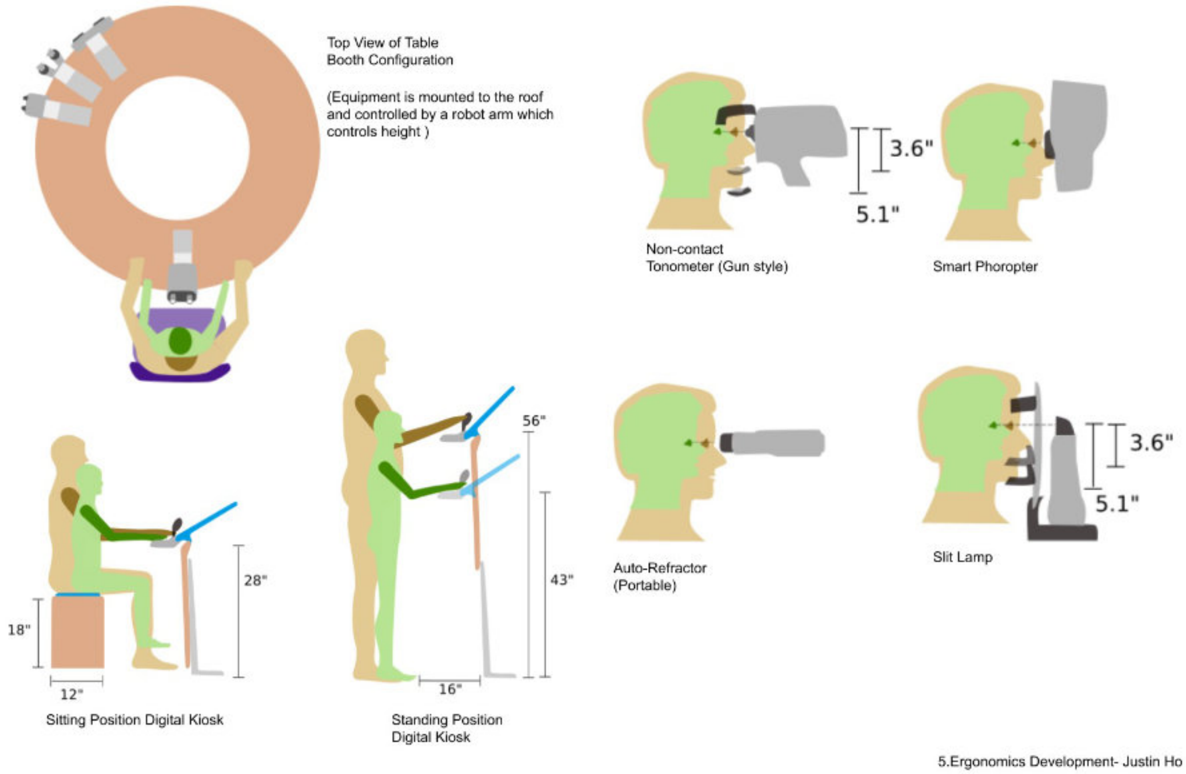


Figure 27 – Ergonomic Analysis of Details

4.5 Concept Realization

4.5.1 *Design Finalization*

Different form factors of the booth were still being experimented upon as well as the overall design language. The idea of having an external optometry booth that had greater control over its operating hours, its privacy, and it's internet connection was rejected by the professors guiding the project.

Some initial rough sketches were produced of the different designs that were possible. Other students were also consulted for their input on what the final form should look like. The preference for a guided chair with rails was recommended by thesis professors giving the booth a more spacious feeling as it featured improved sight lines. The more open design was unanimously critiqued for its lack of privacy so solutions to address this problem were then later developed as well.

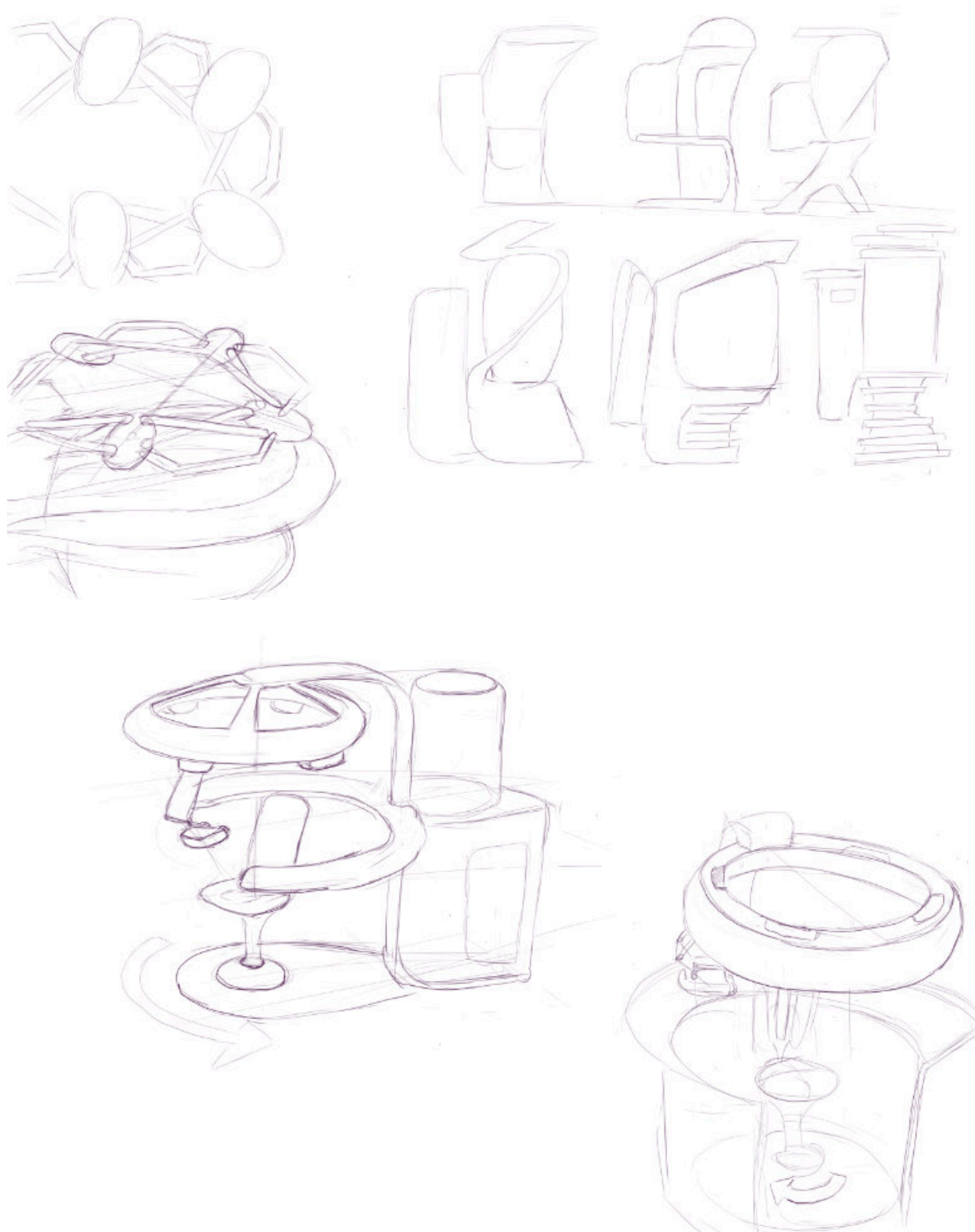


Figure 28 – Extremely Rough Sketches Exploring Different Designs

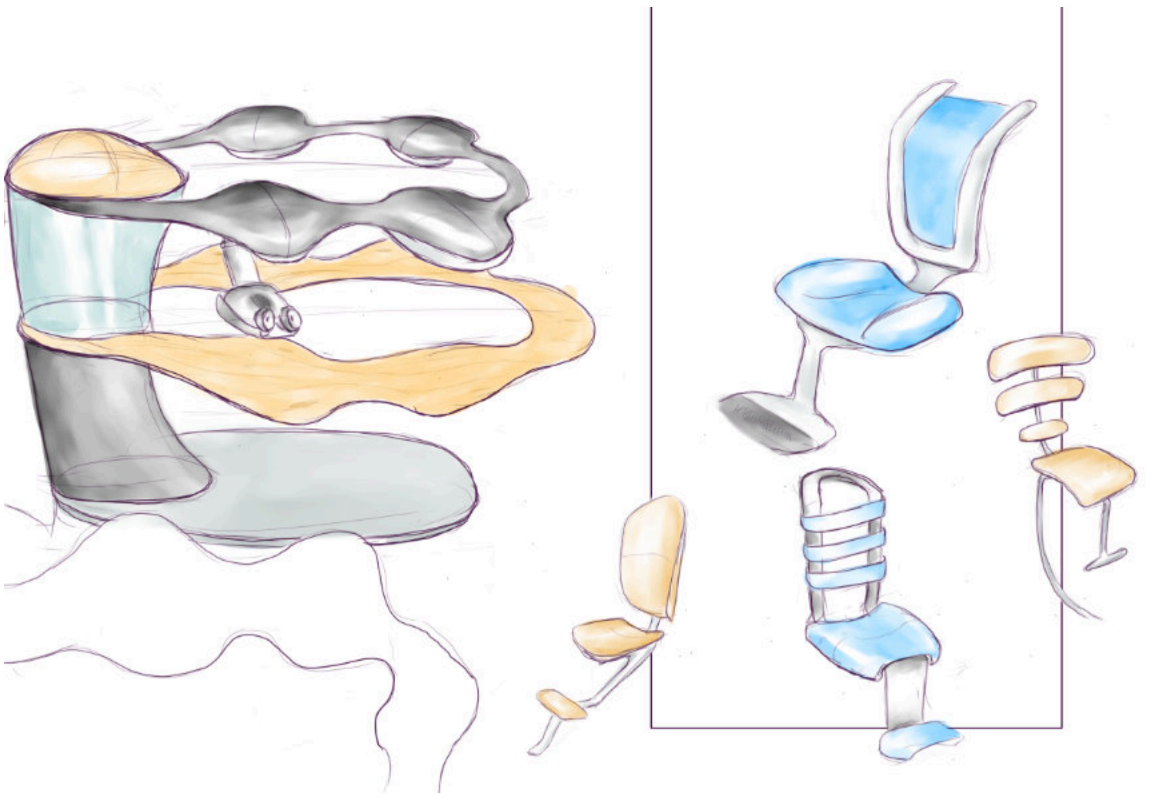


Figure 29 – More Refined Sketches of Potential Design Languages

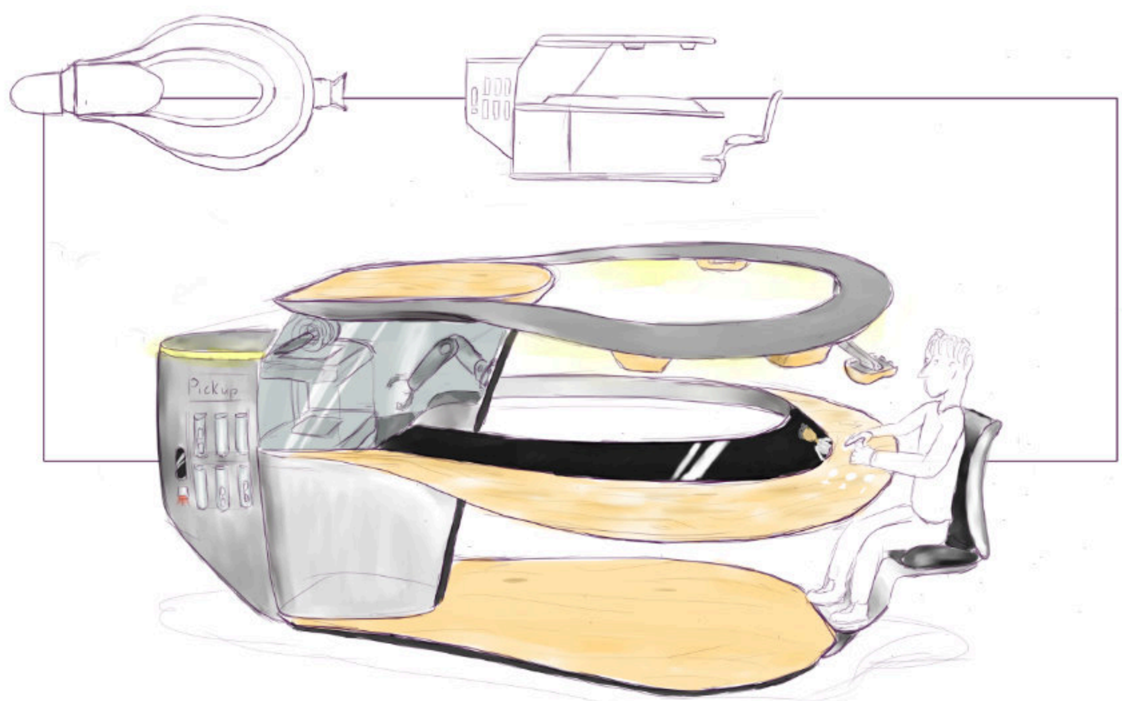


Figure 30 – The Yonic Cantilever Design Chosen for Refinement

With the unintentionally yonic, cantilever design being criticized for its cantilever being too impossible and seemingly too fragile, a more structured and rounded design was developed.

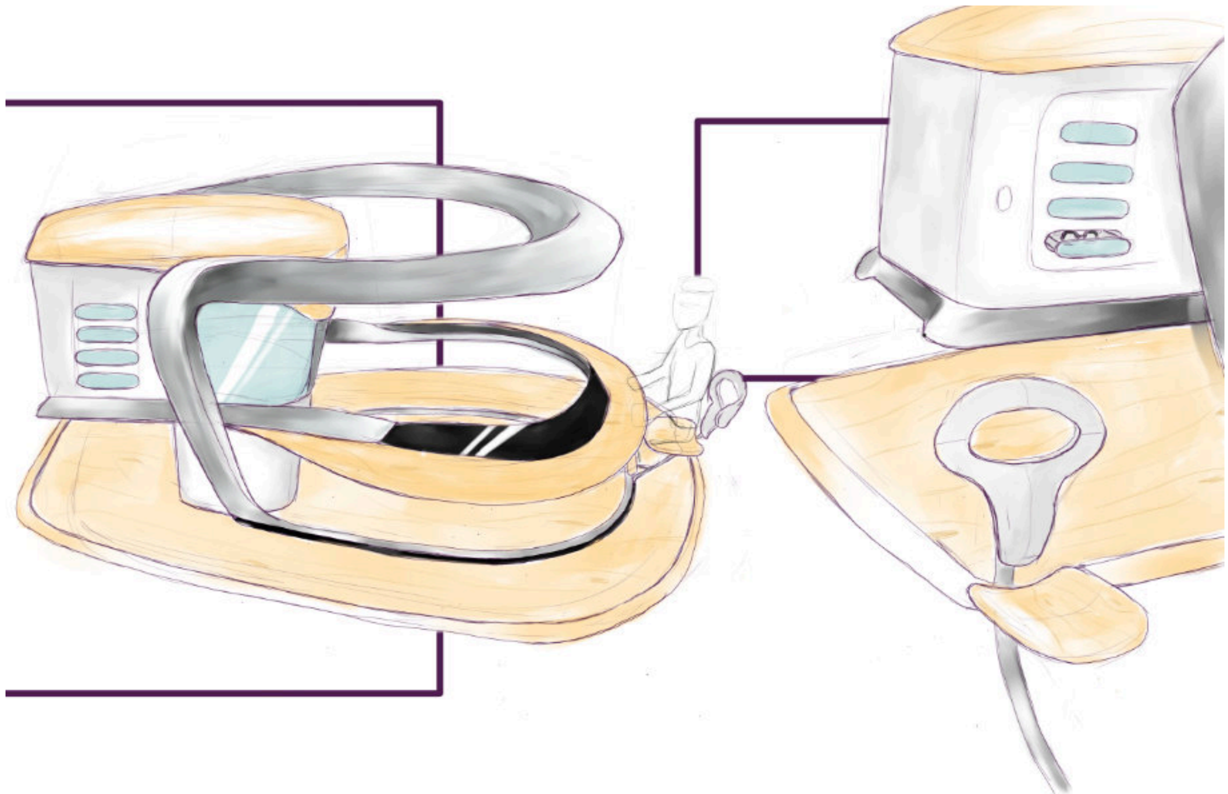


Figure 31 – The Almost Finalized Toilet Bowl-Like Design

The new design combined the more sculpted look of previous concept explorations and features more metal to give the impression of a stronger support structure. It also featured repeating elements such as the rounded ring being repeated in the base, table, and ring. The toilet-bowl design would later be renamed to the “Halo” concept referring to its large metallic ring floating above the user. The ring also houses the main lighting featured in the design which emulates to glow of a halo. The term is not in reference glowing disks featured in classical paintings but rather the rings depicted in modern illustrations which tend to feature a metallic golden ring floating above the head of angels.

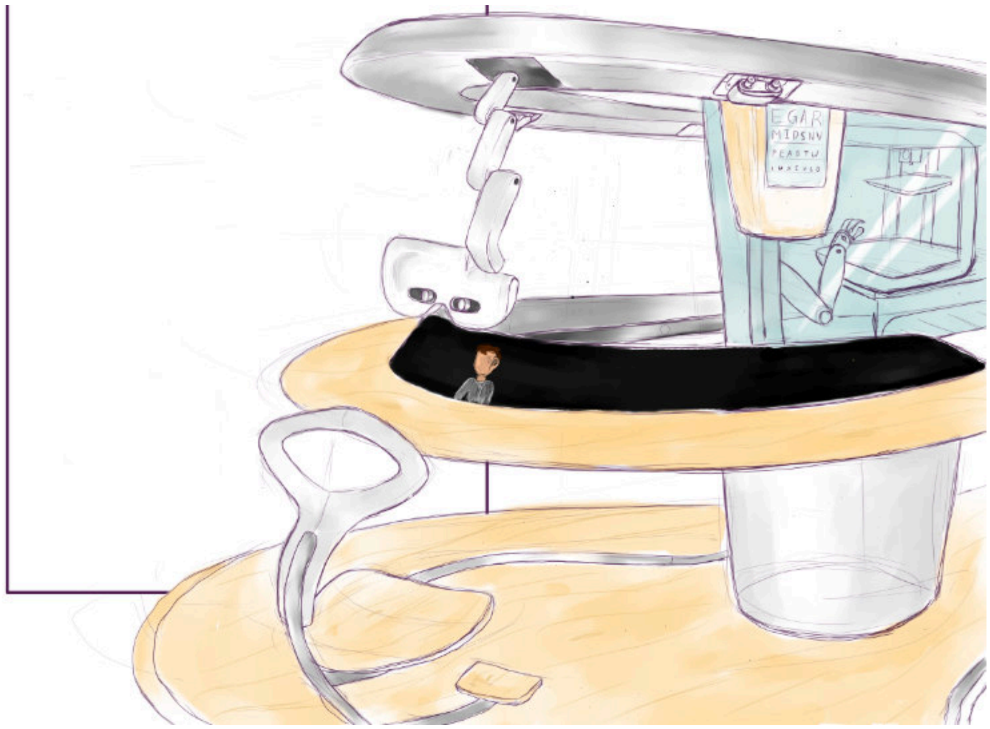


Figure 32 – The Cantilever Ring from a Near First Person Perspective

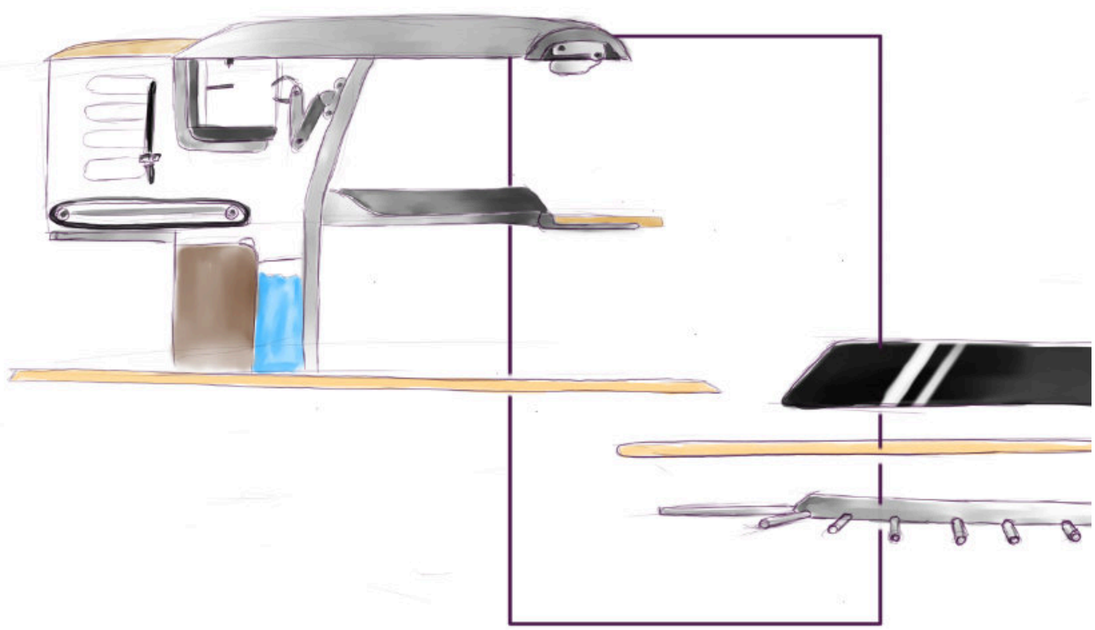


Figure 33 – The Glasses Manufacturing Process and Construction of Cantilever Table

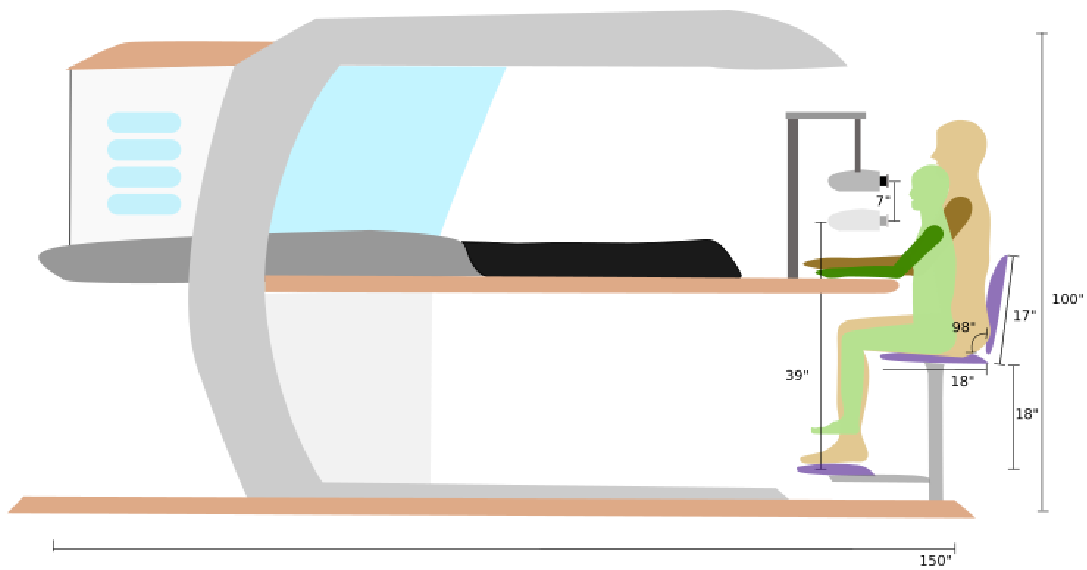


Figure 34 – Updated Ergonomic Schematic Diagram

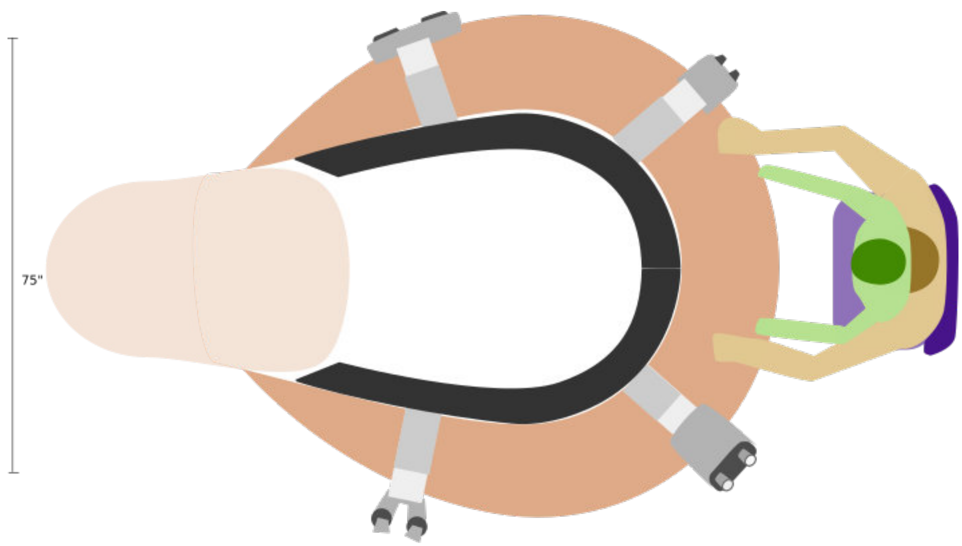


Figure 35 – Rough Top View of Ergonomic Schematic Diagram of Equipment Illustrating The Ressemblance to a Toilet Bowl

With the recommendation to add features to allow for privacy during examinations, several additions were experimented with to resolve the issue.

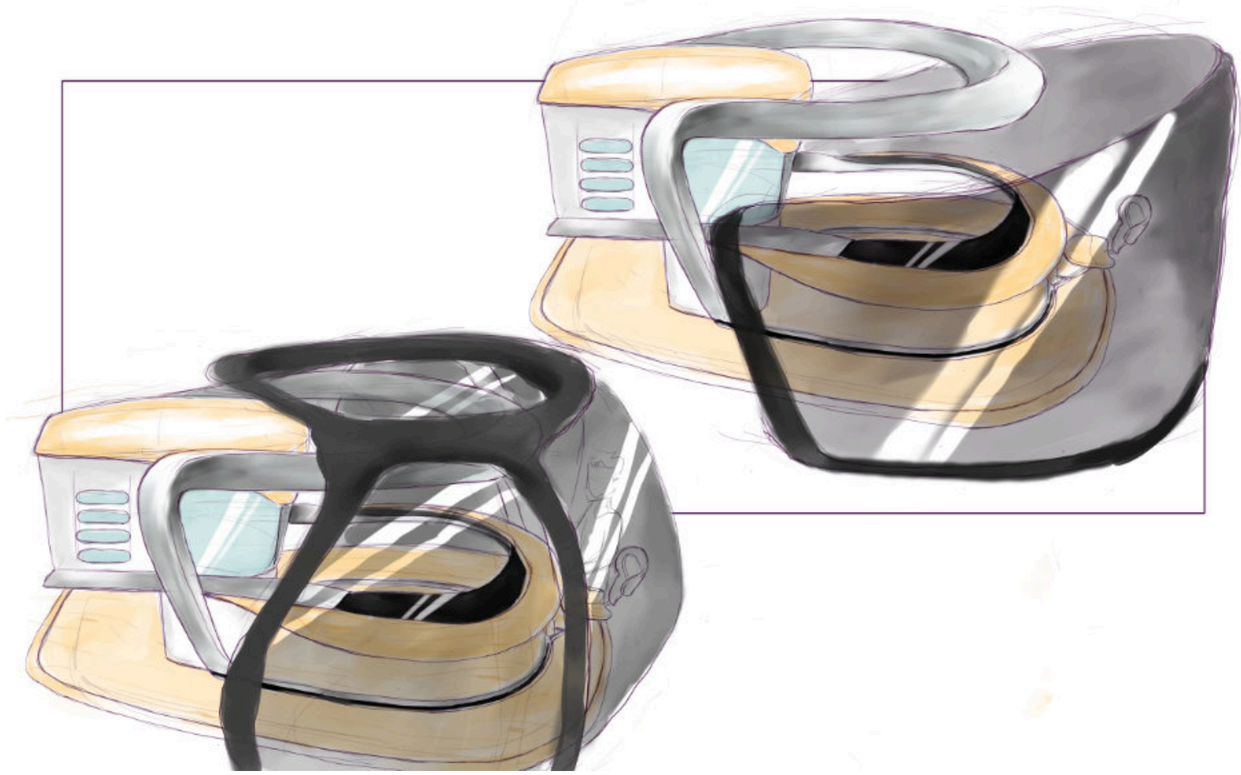


Figure 36 – Different Designs to Create a Private Environment For Examinations

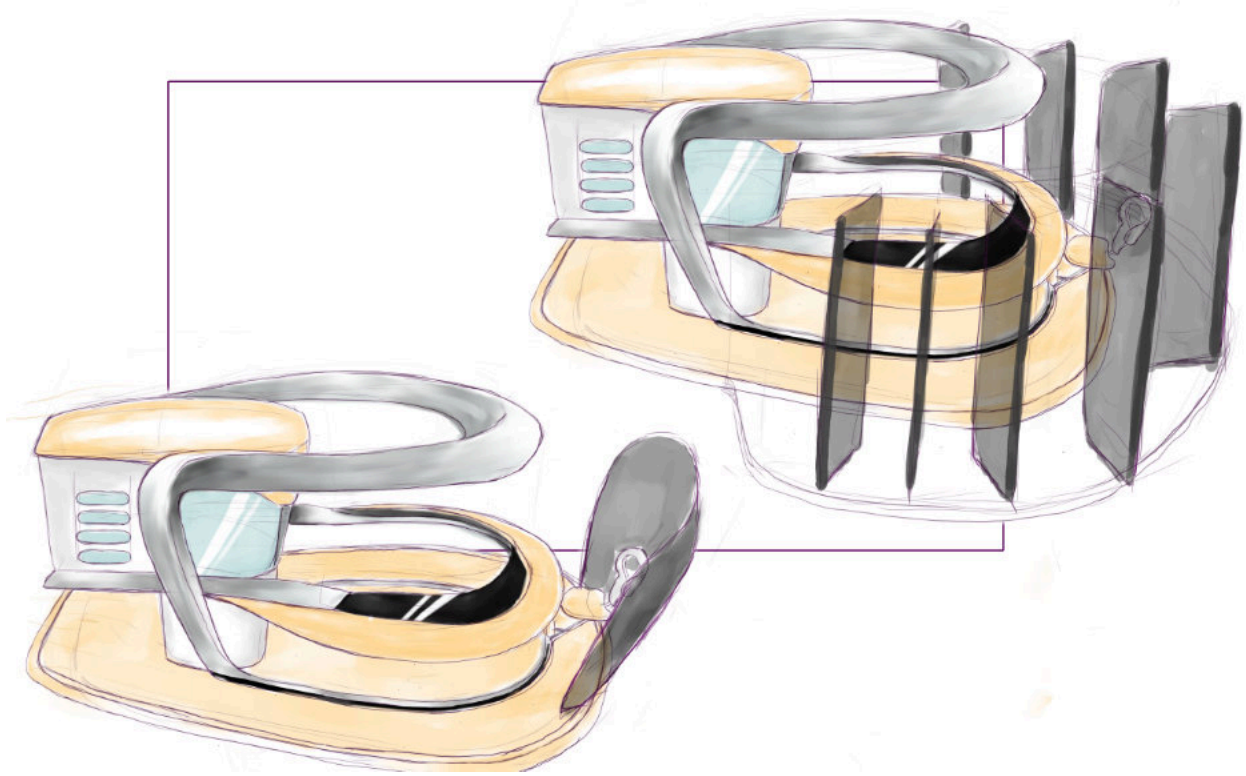


Figure 37 – More Designs to Create a Private Environment For Examinations

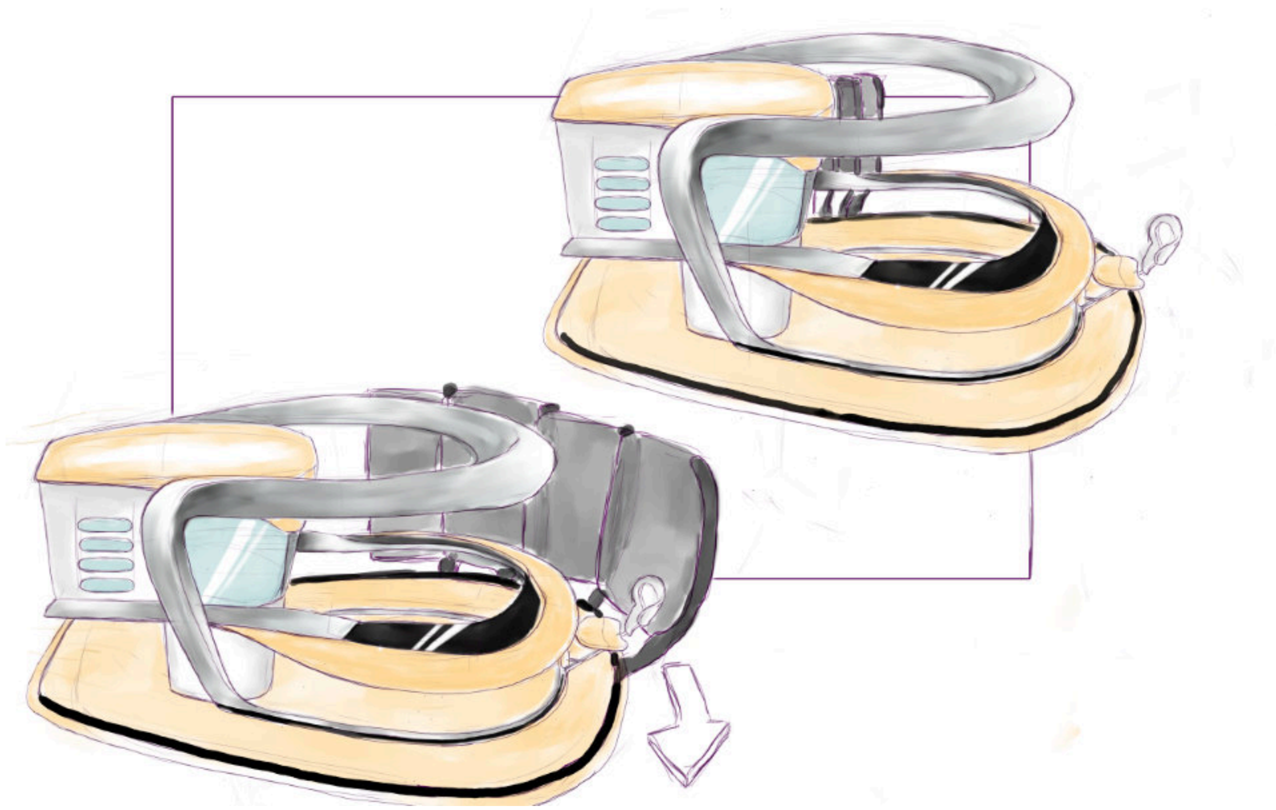


Figure 38 – The Mostly Finalized Design for Creating Privacy

Sliding tinted blockers were added which can rotate to cover the booth. The privacy covers also feature smart glass which can selectively blur the cover so users cannot see through the blockers.

4.5.2 Physical Study Models

To help gauge the proportions of the design and to aid in the development of the CAD model, a scale model was constructed out on paper illustration board. Given the titular ring having illumination, a motion-activated circuit that could last multiple years on battery power was also designed and constructed to provide the needed illumination.

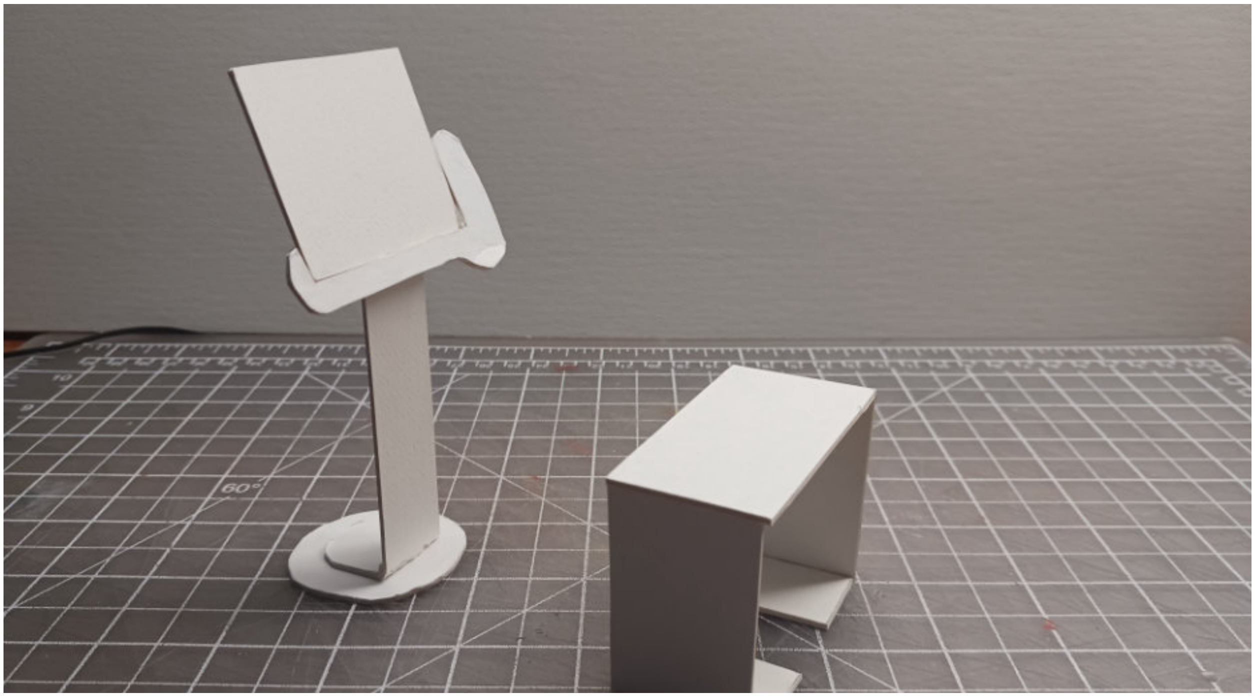


Figure 39 – 10:1 Scale Model of Medical Professional Side Kiosk

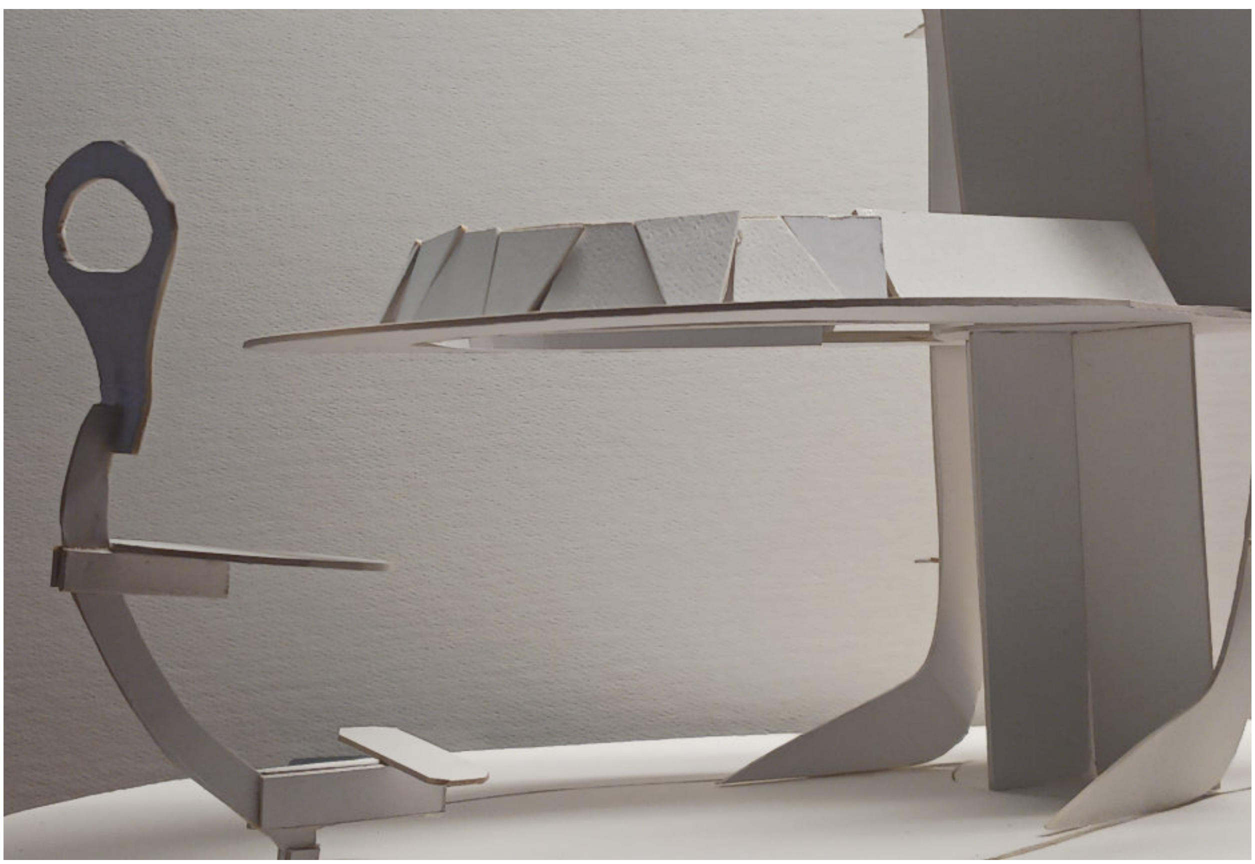


Figure 40 – 10:1 Scale Model of Booth Chair

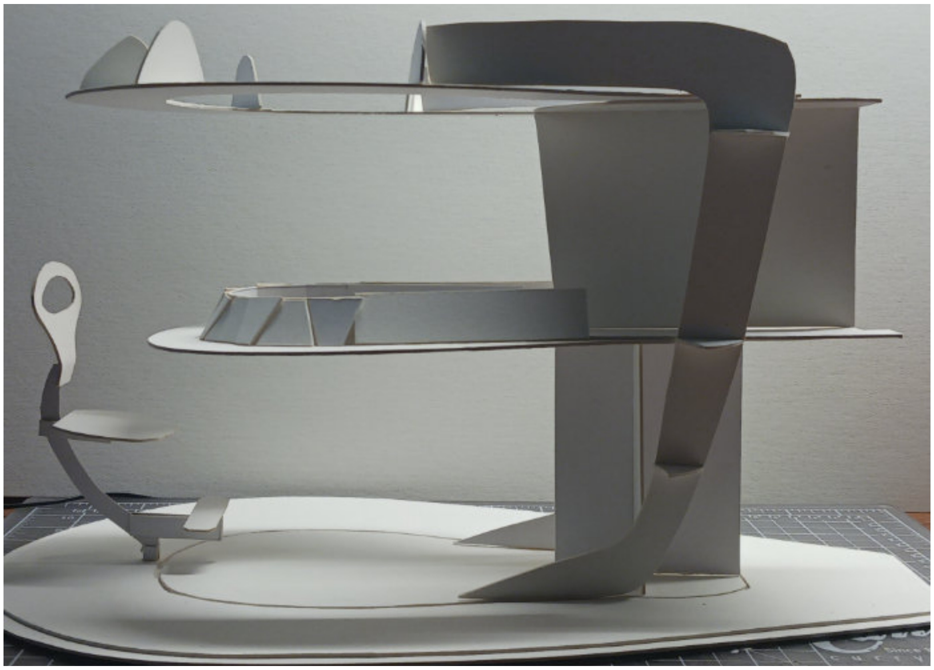


Figure 41 – 10:1 Scale Model Side View

Figure 42 – 10:1 Scale Model of Booth Chair

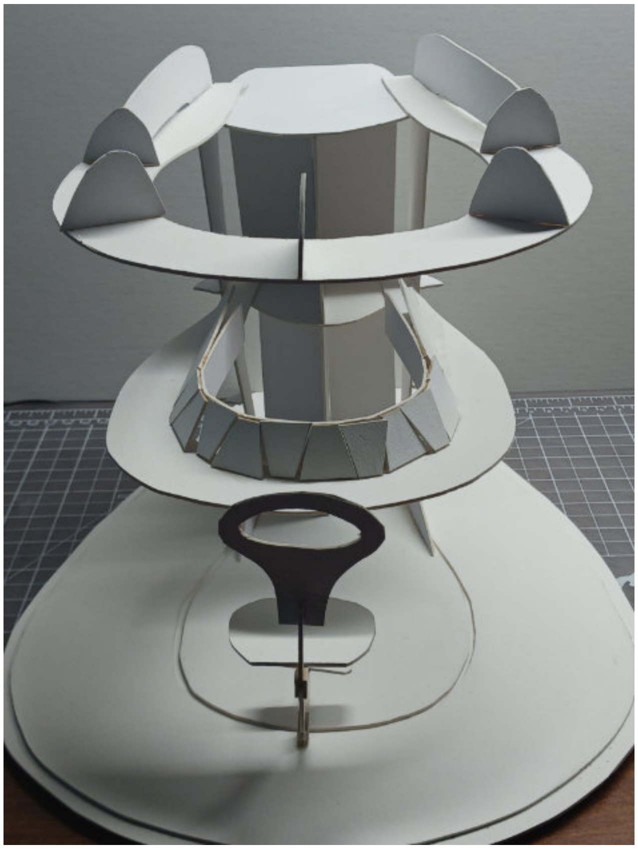
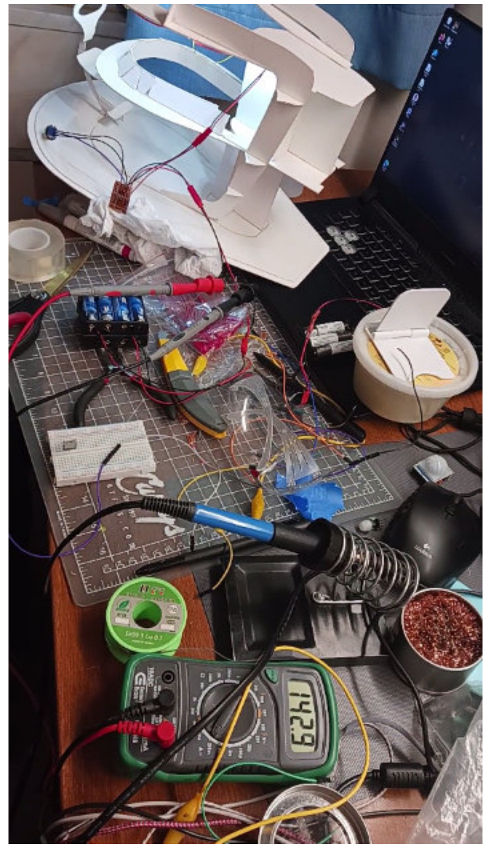



Figure 43&44 – 10:1 Scale Model and Power Consumption Testing of Circuit

Figure 45 – 10:1 Scale Model With Lighting Circuit Installed

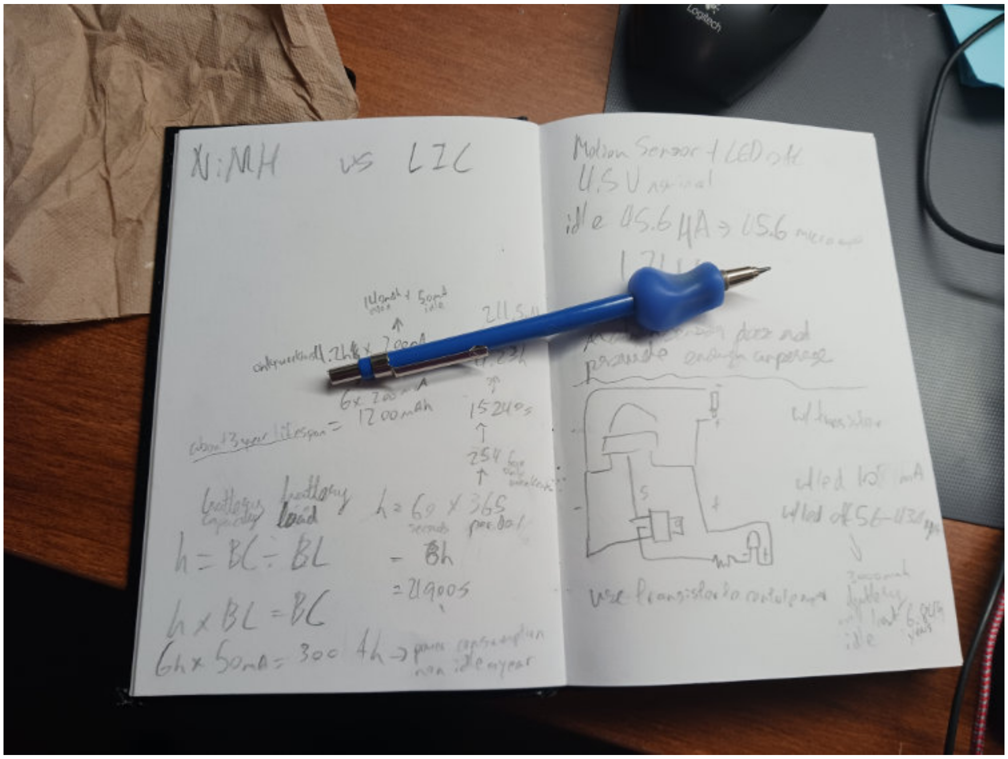


Figure 46 – Sketch of Wiring Diagram and Table Comparing Power Supplies

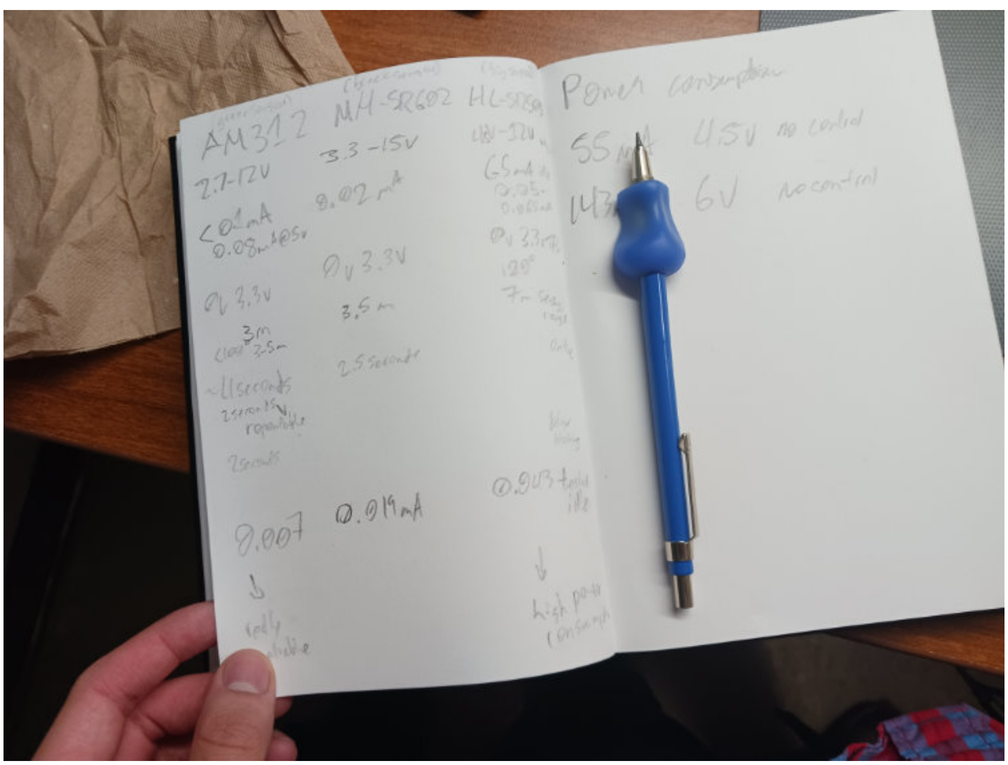


Figure 47 – Comparing Tested Motion Sensors and Power Consumption of LEDs

To make the CAD model, measurements were taken from the sketch model. The size, distance, and the brightness of the LEDs were evaluated using the sketch model. The efficacy of the motion sensor was also tested during this phase. In addition to traditional 3mm and 5mm LEDs, 1W LEDs were also tested. It was determined that the latter provided the best effect on the model.

4.6 Concept Resolution

The concept phase was concluded by a design that connected users to health professionals so that they could receive a fully guided eye exam. The goal was to have as little interface to confuse the users as possible. The aesthetic approach of the design was to make something that felt sturdy but also natural. A combination of metal and a light wood was chosen to demonstrate strength and communicate the warmth of nature. An overall rounded and sculpted look was given to the design so it appeared more friendly and welcoming.

The finalized design mainly looks to address several needs of the user. It looks to create a convenient and physically accessible facility to acquire inexpensive eye wear and receive vision care. It also looks to improving the viability of providing vision care to remote communities as a business model.

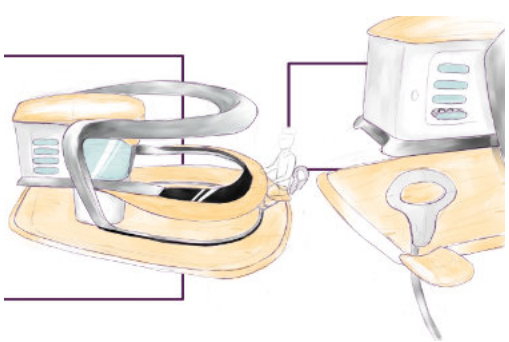


Figure 48 – Sketch of Mostly Finalized Design

4.7 CAD Development

The design of the CAD model in the SolidWorks was not simple because of all the unusual shapes of the design. The model featured many lofts and sweeps that were hanging on by a thread. Help from Professor Frederic and personal friend, Tim allowed for the 3D model to be made successfully. Frederic taught to minimize the amount of linked references to other files in the assembly to prevent the model from breaking. He also taught of many methods of using surfaces to produce more complex forms easily. Tim helped brainstorm and problem solve issues with the model when errors occurred.

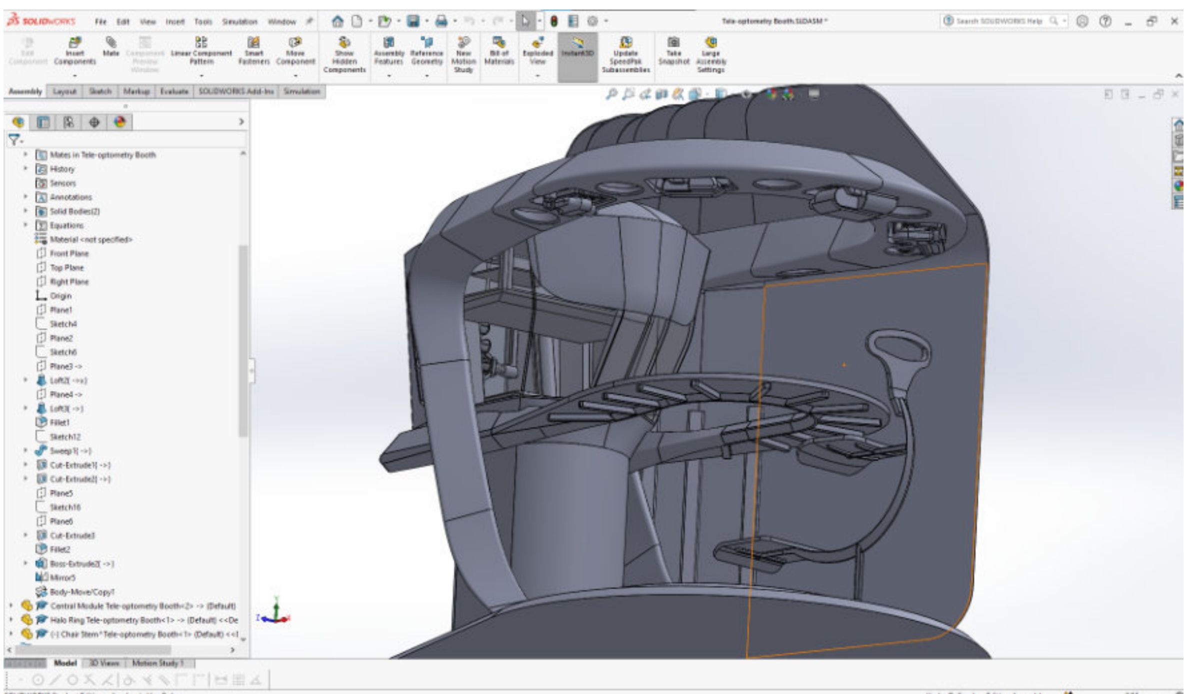


Figure 49 – CAD Model of the Entire Booth

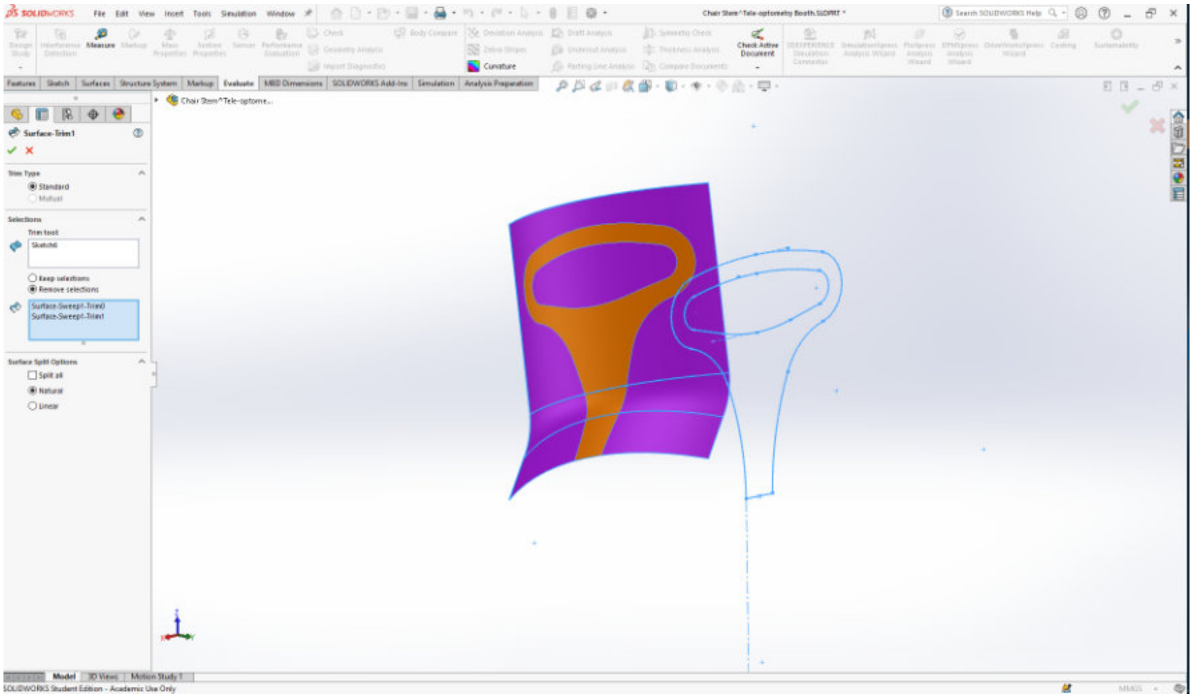


Figure 50 – CAD Modeling Process Using Professor Frederic's Surface Trim Technique

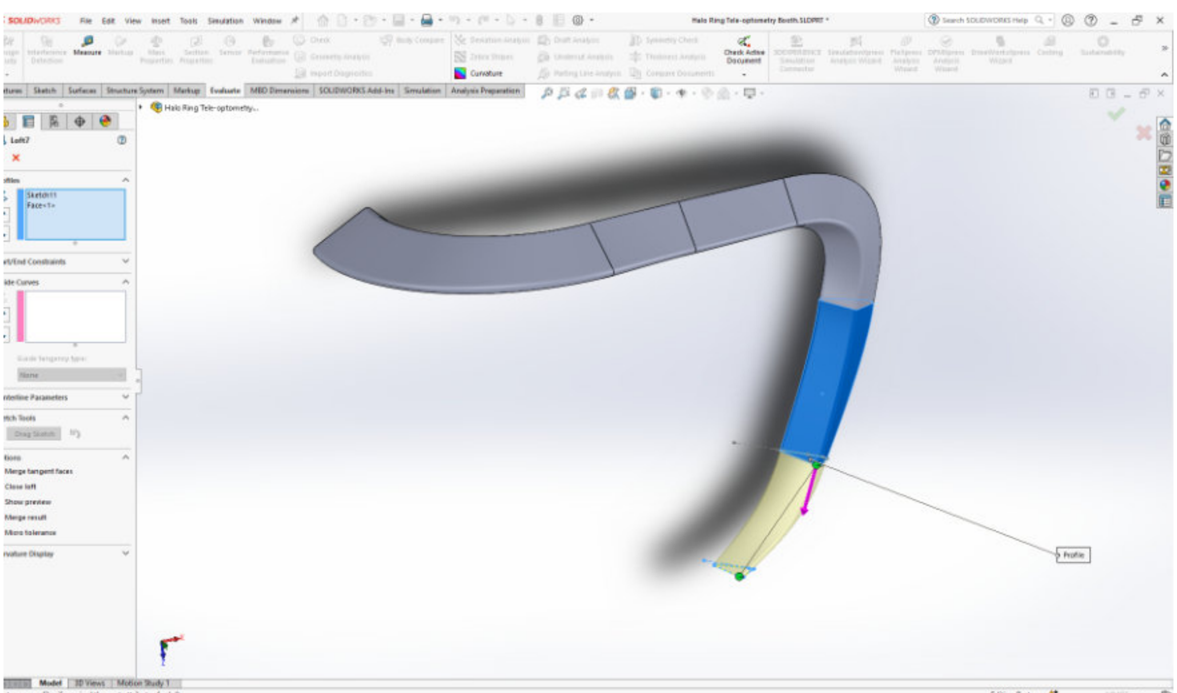


Figure 51 – CAD Modeling Process of Ring

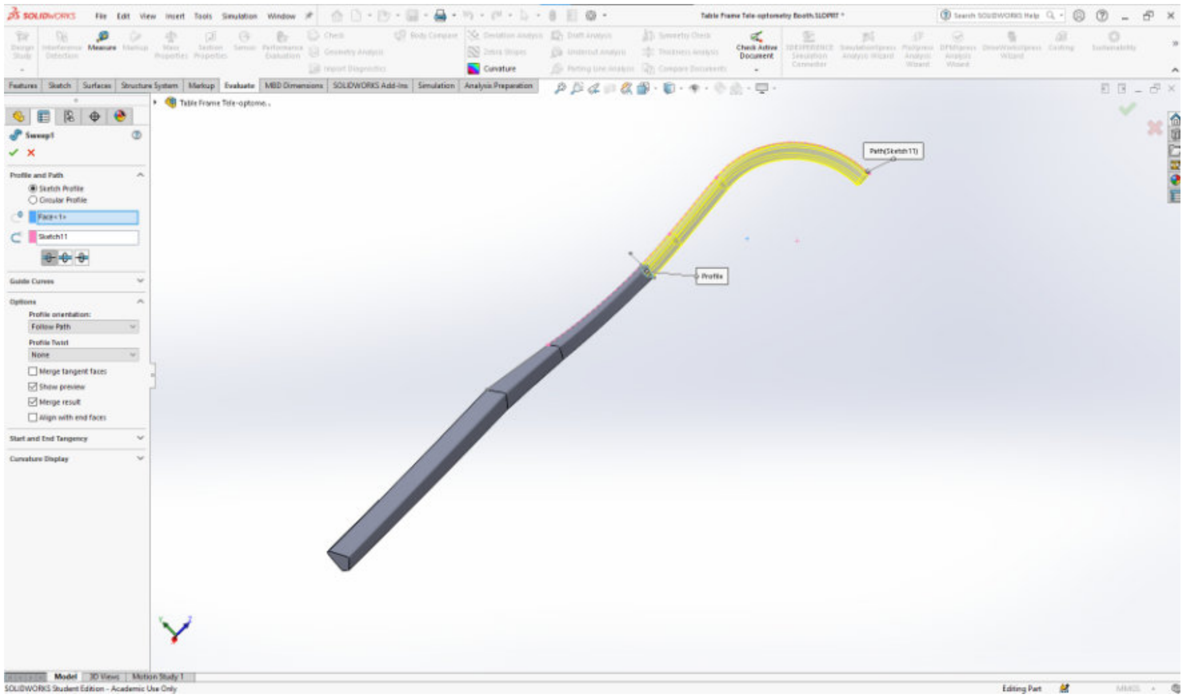


Figure 52 – CAD Modeling Process of Table

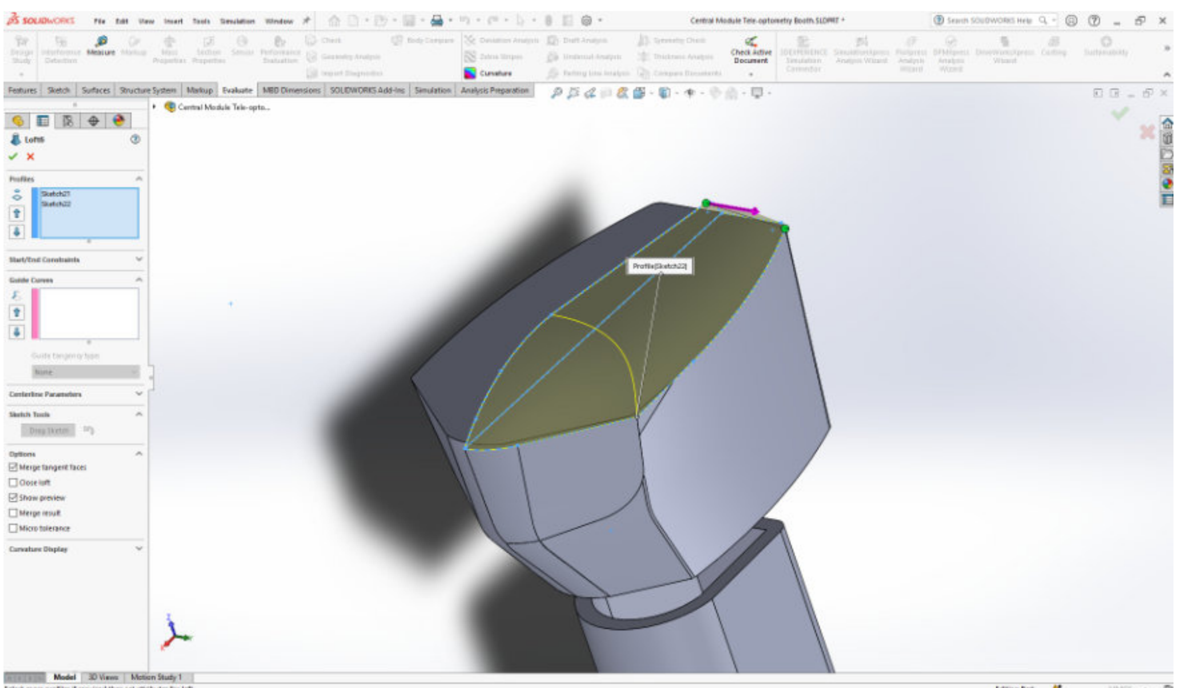


Figure 53 – CAD Modeling Process of Roof

Throughout the design of the CAD model and developing the concepts, it was determined that explaining how this concept functions would not be easily. That is why it was decided that the model would be finalized in Blender. As a newcomer using Blender for the first time in a major project, many tutorials were used. The model was first separated into individual components, textured, and a scene was made. Then parts were parented and empties were made to allow for parts to model to be animated properly. The origin of each part also had to be readjusted so they would rotate in the correct axis. Finally, a software called fSpy was used for the insitu pictures to help ensure that the grid plane in Blender was matched with that of the image.

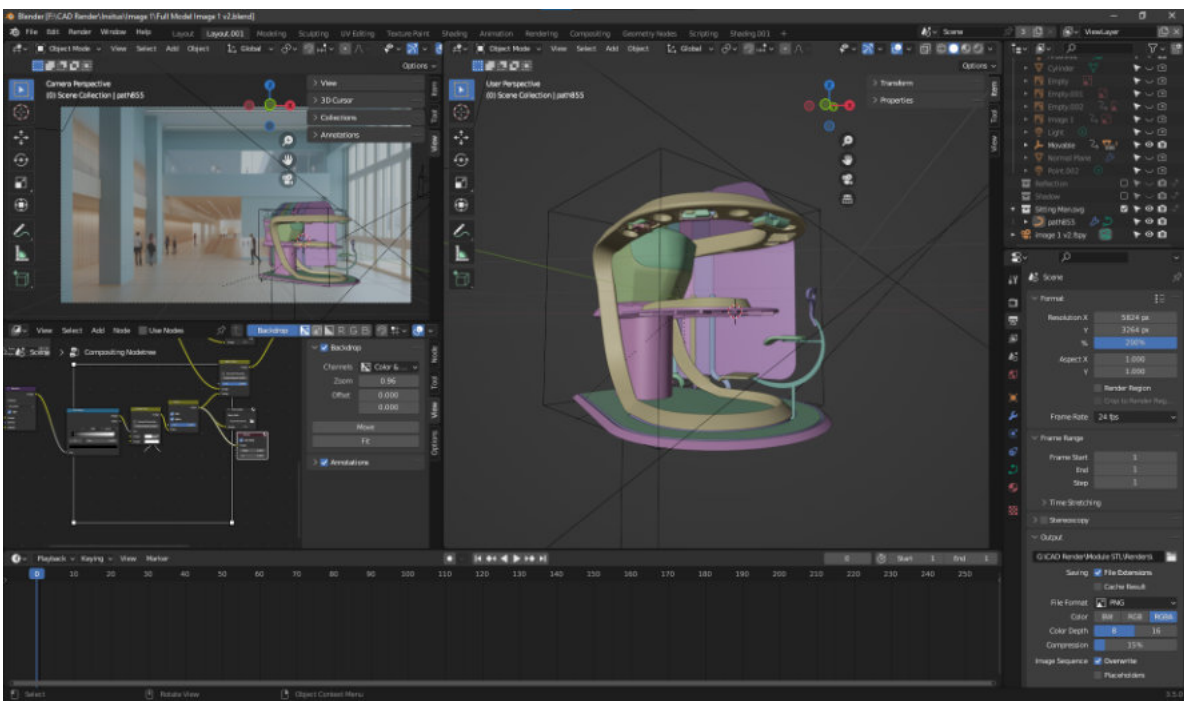


Figure 54 – CAD Modeling Process In Blender

4.8 Physical Model Fabrication

The original CAD model was constructed in the full-scale dimensions so before it could be 3D printed, it needed to be scaled down. The scaling function in SolidWorks only functioned for several parts before it broke the entire model because parts were constructed in a different order than which they were scaled. This caused referenced relations to break down. As a result, some parts were scaled down in SolidWorks and others were scaled down in the 3D printer's slicer. Some modifications also needed to be made in the needs of the physical model such as hollowing the ring to allow for LEDs to be wired through.

Finally, the scaled models were 3D printed on an old $250 printer bought on Kijiji and placed in a dormitory room closet. The printer was specifically chosen because it has a large print volume which could fit the relatively large parts of the model. The model was printed on several rolls of PLA + which amounted to around $50-75 worth of filament. Many of the prints took several attempts to complete. Given the low cost of the printer, this outcome was largely expected and enough time was allocated to reprint failed parts. The extreme height of many of the parts was the cause of several print failures. In the future, it would also be preferable to print the model at a shorter layer height so less sanding and filler would be required to smooth the print.

In the next steps, filler was applied to all the parts and sanded down. Unfortunately, there was not adequate time to finish each part to a reasonable standard which is why some parts have cracks and craters. Filler primer was also used but there was not enough supply in the local department stores and hardware stores so it was

Figure 55 – Removing Support Material and Filling Gaps with Glazing Putty

Figure 56 – Epoxying the Three Different Parts That Made Up the Ring

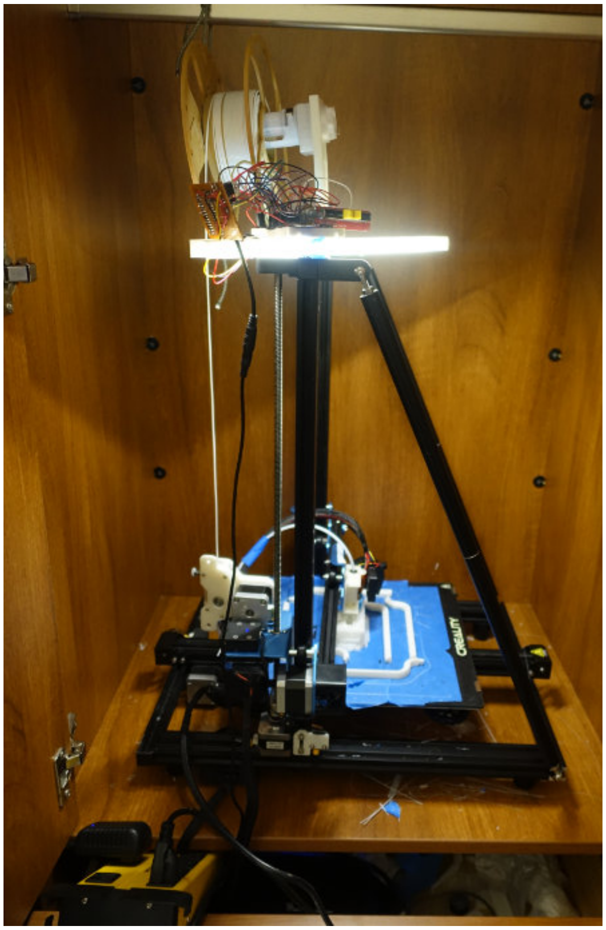
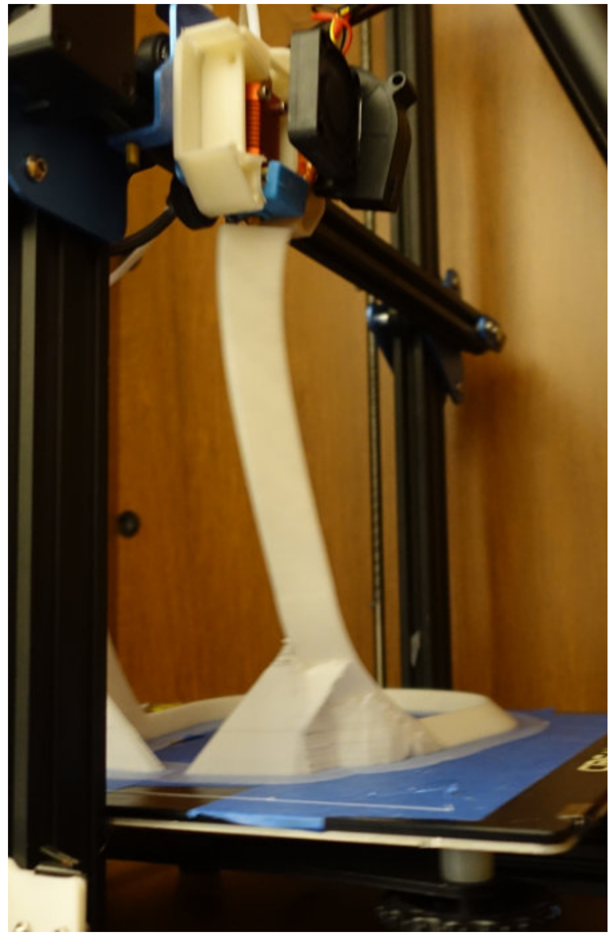
 

Figure 57&58 – $250 3D Printer from Kijiji Printing the Bottom Portion of the Ring

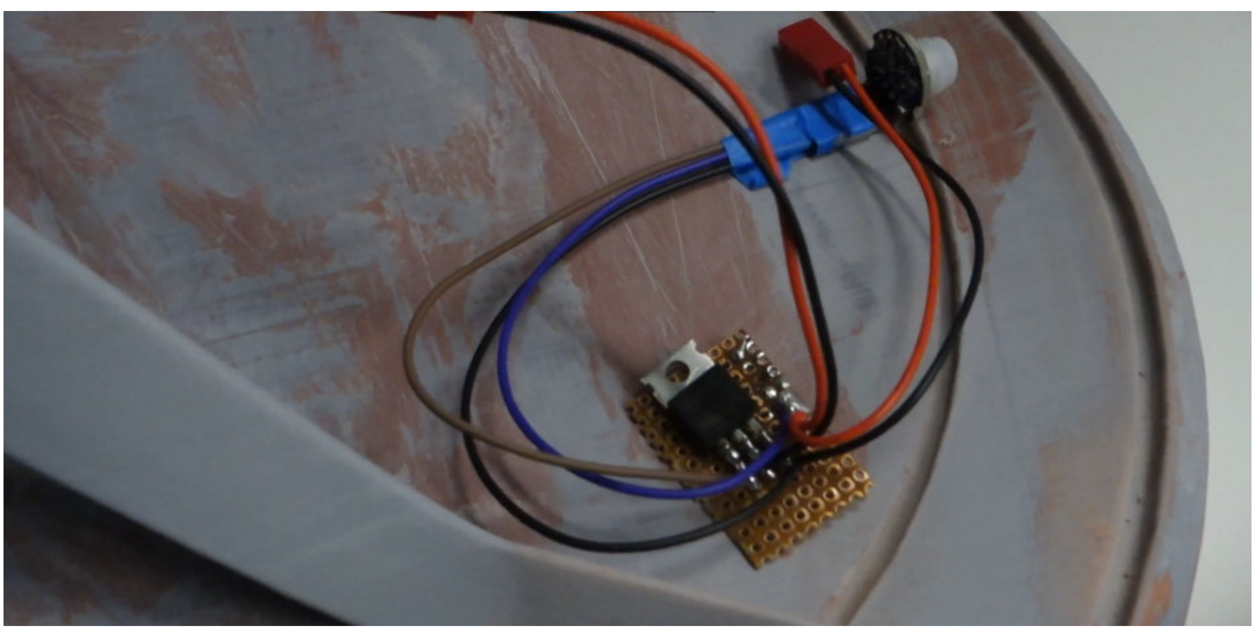


Figure 59 – Simple Motion Activated Circuit Which Controls the LEDs

Figure 60 – Priming the Sanded Top Portion of the Ring

used only at a limited capacity. This could be due to the sudden influx of demand for filler primer from industrial design thesis projects at Humber College. A faux wood vinyl was applied to each of the wooden surfaces. With the help of Tim, the most challenging vinyl was applied to the roof of the 3D printing module. The remaining parts were spray-painted.

CHAPTER 5 - Final Design

5.1 Design Summary

Halo is a vision care system that features a tele-optometry booth and digital kiosk. It functions by connecting customers to eye health professionals like optometrists through a booth located at communal hubs. These communal hubs are likely frequently visited by members of remote lower income communities which allows for easy accessibility. Eye exams and consultations can be done simply by dropping in and without the need for an appointment. By having many tele-optometry booths scatter throughout many communities, the demand for vision care can be accumulated and distributed to eye health professionals working part time on a flexible schedule.

With Halo, customers will be able to access vision care on their own schedule and without needing to travel far. Customers also do not need to make multiple trips with glasses being manufactured on-site. The system is economically viable by allowing business owners to tap into the combined significant demand of multiple communities for vision care services. Supplying vision care booths will also be significantly easier because the booth operates on using raw materials for constructing each frame design. Finally, health professionals will be able to reduce on time spend commuting by working remotely. They can also free up more time by creating their own schedule.

To get started, customers will walk into a facility like a community center or library with a Halo booth. They don't need an appointment, they can just drop in. They take a seat on the chair which will detect someone sitting. The chair is motorized and follows a rail. It will then move and turn the customer to face the screen which is when they will connect with an on-call eye health professional, likely an optometrist. Once connected, the consultation and eye examination will begin. The space is first closed off with motorized tinted polycarbonate panels which will surround the module. Each panel is also smart glass meaning that the panel can be frosted/blurred selectively. These measures are activated to give the user privacy during their eye exam. The eye exam will work with the optometrist guiding the chair remotely and activating the different equipment. The booth by default features a non-contact tonometer, slit lamp, auto-refractor, and a set of smart phoropters with a camouflaging visual acuity screen. All of the equipment is mounted to a robotic arm which adjusts for the height and eye position automatically.

Once the exam is complete and the user requires glasses, an in-screen face scanning module takes a 3D scan of the user's face. Then it will generate a 3D model of the frames of the user's choosing and customize it to the user's face using the 3D scan. With the model constructed, it will then be printed out of a bioplastic and a soluble support material on the 3D printer located in the central hub of the booth. After several hours, robotic arm on the inside of the central module will receive the finished 3D print and submerge it in a solvent bath and place the frame in a special lens edger. The lens edger stores a selection of prescription single vision lenses, cuts them to the frame shape, and mounts them with the help of the robotic arm. Finally, the finished glasses are moved to a pickup box with the help of another robotic arm and a conveyor belt. Once in the pick up box, the user can use their phone to unlock their pickup box and start using their glasses. The entire process occurs so quickly that a customer can receive an eye exam and use their own personalized glasses within the same day.

Halo is able to improve the lives of individuals in remote lower income communities by providing accessible vision care services and supply glasses. By receiving access to these services, users will be able to be more productive, be able to operate vehicles more safely, and have a better quality of life among other benefits.

5.2 Design Criteria Met

5.2.1 *Full Bodied Interaction Design*

Halo was designed from the beginning to be easy to use for end users. It is designed to be a guided experience in which the user is controlled by and communicates with a real eye health professional. Much like an aged, fine, fermented, alcoholic beverage, the experience of having a consultation is able to be flavourful and rich because of this genuine human connection. This means that customers can receive a more real experience compared to that of a more automated or DIY approach. Any issues that users may encounter can be discussed directly with the healthcare professional creating a seamless experience and a human to human bond can be made.

The availability allows for drop-ins means that customers do not have to deal with the frustrating and potentially difficult process of making an appointment. The ability to have glasses manufactured according to the shape of the customer’s face also means that users will not have to check the fit of glasses after receiving glasses.

To improve the ease of providing care for medical professionals, automatically adjusting eye equipment and a dedicated digital kiosk was also implemented to the vision care system. The digital kiosk is able to emulate the experience of using the analog controls of existing examination equipment. The digital kiosk also features a standing and sitting configuration to discourage care providers, an option that would discourage a sedentary lifestyle.

5.2.2 Materials, Processes and Technology

The scope of the tele-optometry clinic calls for the design of furniture for a large installation similar to that of a retail booth or exhibition trade show installation. The product will likely be produced in small runs and require several different structural and decorative materials to construct. In order to determine the ideal materials and manufacturing techniques, the materials of related structures will be evaluated and the sustainability, health, and safety considerations will be evaluated to determine the best materials and processes for the booth.

Before considering methods of manufacturing and materials, a literature review was conducted as a form of research. Though it is difficult to find scholarly literature on the construction and materials of retail store fixtures and exhibition booth fixtures, many companies offer promotional websites which highlight popular materials (UCON Exhibitions, 2022). Many popular materials of exhibition booths are not very long lasting because of the temporary nature of the booths. The construction of the booth itself is also often very modular so that the booth can be constructed and taken down easily (Display Wizard, n.d.). Using this understanding, more solid construction materials should be considered. Out of the common materials listed, literature into solid structural materials like plywood and steel was done. Long-lasting materials like glass and clear plastics like acrylic and polycarbonate were also investigated for some of the transparent barrier elements.

With most of the literature that was found on the subject of materials, they often evaluated the different uses of the materials that were studied along with their applications and environmental impact. Many websites that supply plastics provided some background information about the possible use cases for each material and the strengths of each material (Thomas, 2021; Thomas, 2022). These sources often outline how polymers are generally more versatile as they feature properties that make them more resistant to shattering and are lighter. Research on finding similar use cases of products using glass or polymer panels was conducted to conclude the advantages of each (Durden, 2019). With regard to the environmental impact of the materials, each has their own environmental concerns such as the high-energy demands of manufacturing glass and the pollution during the disposal of plastic. (Stefanini et al., 2021) Other studies suggest reducing the toxic additives to plastic and improving recycling process to improve the environmental impact of polymer solutions (Broniewicz & Broniewicz, 2020). Finally, some research was reviewed on the feasibility of electronically dimmable glass for the use of preserving privacy. The research discussed how the technology functions and the current limitations of the process. Though there are not very many sources that discussed these materials holistically, these sources are able to provide a starting point for material selection and assessment of sustainability.

Steel has been well established as a popular structural material that allows for the construction of buildings. A study was found which outlines its advantages in its great strength, low cost, and its ability to be reused so it can reduce its environmental impact (Broniewicz & Broniewicz, 2020). Plywood’s widespread adoption and popularity in furniture and construction has also been covered in various articles discussing its environmental impact (Ali et al., 2024; Jia et al. 2019). They highlight some environmental concerns with manufacturing and cultivating plywood and plywood products, with the energy used to process the material being considered and the hazardous emissions that can occur from the production.

Overall, there exists some literature that discusses the possible materials that could be used for the construction of a structure like a tele-optometry clinic as well as material that discusses the environmental considerations of using those materials.

Figure 61&62 – The Internal Metal Structure of An Exhibition Booth Covered by an Outer Layer and Frame and Module Which Features the Cladding

However there lacks a comprehensive analysis of all of these materials for a tele-optometry clinic. Even though there exists a large quantity of material discussing the sustainability of the materials that are used in the clinic, the more permanent nature of the clinic may change the sustainability considerations of the life cycle analyses that were performed in the studies as they will be used in a different type of product.

Determining the materials and manufacturing first started with the outer frame. The outer metal frame that houses the testing equipment and the overall frame construction will be made with a steel based on the research done benchmarking similar booth-style products. However, due to the organic forms and the inability to use more traditional extruded materials, traditional steels used in buildings may not be ideal. Considering the more organic shapes of automobiles, the ability to weld and form the material may suggest that a high-strength steel may be ideal. The tensile strength may also be able to support the cantilever structure better (SSAB, n.d.; Neenu, 2020). The forming of the frame will likely have to take place by using a hydraulic press and a mould with parts of the frame later assembled using welds. Then later maintenance features like panels can be attached using fasteners. Non-frame items like the base to the table surface can likely be made from prefabricated extruded steel rods or other prefabricated steel elements. This approach is similar to the process that existing exhibition booths use with an internal structure that provides strength and a lighter outer fabric or vinyl outer layer.

Plywood for use on the desk surface was decided so that the touchpoints for the user would be warm and inviting. Plywood is a common material for manufacturing existing furniture which would be familiar to the user. Manufacturing plywood surfaces as large as the round table surface can be done by manually cutting the smaller segments of the round and attaching them together using an adhesive. The adhesive would only serve to match the seams of the plywood and would not serve a structural function. The top lid of the printing module would not be able to be easily bent so that would have to be milled using a CNC machine. Common types of plywood that would be suitable for this application would be birch or oak but can vary if a specific hue is desired. If milling on a CNC machine is not possible, it may need to manufactured with plastic and have a faux wood texture applied to it.

Finally, glass would be preferable for the manufacturing module enclosure as some 3D printing technologies require heat which may affect the properties of polymers negatively. However, given the complex form of the manufacturing module, it may only be possible to manufacture it out a transparent polymer. Polymers would be used instead in the movable privacy screens. Polycarbonate is chosen for this application because of its durability and weight. A treatment such as a lamination process with smart glass can be done to improve the privacy of the product (Switchglass, 2017). Information on manufacturing a curved OLED display was not available likely due to the futuristic nature of the technology and the interests to keep its manufacturing details out of the public.

Looking at similar existing products to compare the sustainability of the booth is rather difficult as existing products often have very different scopes. Exhibition booths typically do not have a long lifespan and as such, they may produce a lot of waste in the signage and low quality materials (UCON Exhibitions, 2022). However, after removing the disposable elements, it is often possible to reuse much of the frame elements and the backing to the signage (UCON Exhibitions, 2022). Efforts have been made to improve sustainability in large structures made of metals such as automobiles as well. This often takes place by ensuring proper disposal of the vehicle where almost all of the metals are recovered and reused elsewhere (Lehmphul, 2014). Proportionally, the glass and plastics recycling in the same vehicles are noticeably worse with the separation of materials causing a major issue in the disposal process. To implement these findings into the design of the booth, easily recyclable and valuable metals like steel and aluminum are frequently featured in the design of the booth. Unfortunately, the use of glass in the design is highly unlikely given the complex forms, heavy weight, and potential safety risks that are associated with it.

The health implications of the product are largely related to the certifications and development of the eye examination equipment. The highly compact eye examination equipment technology currently exists as seen in the product benchmarking segment of the report. These devices can be integrated into the booth but will require certification from medical and optometrist equipment quality assurance bodies of Canada or any of the countries that the booth operates in. The plastics used in the 3D printing process may also pose a risk to the user if proper materials are not selected. Materials that are compatible with contact to the human body will have to be considered. Given the rapid innovation of the rapid prototyping industry, it would be difficult to predict which materials would be ideal but materials like PLA which have been used in cutlery and PHA which has been used in biocompatible medical devices could be considered (Green, 2022). Finally, 3D printing companies like Formlabs also make resins show promise as well as they are designed for biocompatibility in medical applications (Formlabs, n.d.).

Some safety hazards in the existing design include the moving components of the testing equipment arms, the moving chair, and the moving dividers. The speed and the engineering of the rails could potentially cause loose clothing to be caught in machinery. Referring to similar products like stairlifts, input from the user, slow acceleration, and slow movement may aid in ensuring safety (Mckenzie, 2020). Other safety hazards from the heat of the 3D printer can be avoided by restricting access to the printer with an enclosure. Using fire-resistant materials such as glass, fire resistant polymers, and steel to surround the printer may also aid in providing protection to the user. Some materials may also have emissions when heated, those materials will require a filtration unit to ensure no harm comes to the user.

After researching a variety of different materials and comparing their environmental impact, the end of life care for the materials were made a large priority in the selection process. Final materials include a significant use of steel because of its longevity and its ability to be easily recycled in the form of scrap metal as mentioned earlier. The use of thermoplastics in the design for the booth and the manufacturing of the glasses was also made because it is also able to be recycled. In addition, thermoplastics tend to use less energy to produce compared to other materials like glass which affects other metrics for calculating environmental impact like greenhouse gas emissions. However, glass alternatives like acrylic and polycarbonate are rarely recycled and are rarely accepted in recycling centered.

There are difficulties in recycling plastics in the frames due to a lack of economic incentives to recycle. This need may require a system that could be later implemented to encourage proper disposal of glasses frames when they are no longer needed. An incentive could come in the form of a discount or a refundable deposit when the frame is disposed of in a related facility which may encourage recycling effectively.

The recommendation by thesis professors to implement the exciting innovations of composite materials in the design was considered because it could make the design seem more innovative. However, ultimately this idea was firmly rejected due to the hazardous nature of manufacturing (Fibrous Glass | NIOSH | CDC, n.d.) and the potential risk that some suspect may occur when handling these materials (Russell, 2022). Their difficulty to recycle or dispose of (Yang et al., 2012) is also well documented and becoming a growing concern. In addition to these concerns, composite materials are also expensive to manufacture with and can have a significant environmental footprint. These innovative composite materials would better be reserved for applications that truly require them to function effectively instead of being chosen for every application simply because it has a reputation of being associated with cutting-edge products.

In conclusion, after evaluating materials found in similar products and their environmental impact, it has been determined that the main structural elements would be made out of a high-strength steel and plywood. Decorative and clear elements can be made with glass or polycarbonate when not possibvle. These materials were chosen for their suitability in a tele-optometry clinic but also for their relatively low environmental impact.

5.2.3 Design Implementation

Implementing the current design would require the development of several components that need to be custom tailored for the application in Halo. Testing equipment and the robotic arms that feature the same kinematics as the ones featured in the concept would likely be priorities. A lens edging machine that is able to store lenses and fit in such a compact space would also be needed. Many existing products may already exist but require small modifications to be suitable for the application in a tele-optometry booth.

To outline all the components that are likely required to produce the design, a bill of materials was made. Price estimates featured in the bill of materials is likely to different as time passes because many technologies like 3D printers can be exponentially less expensive in only a few years. Costs of custom construction can vary with the rise of automation. Only very rough estimates are provided.

Though examples of steels are not corrosion resistant, corrosion-resistant materials would be preferable over materials prone to corrosion.

Component	Material	Manufacturing Process	Estimated Cost	Quantity
Main Components				
Frame Structure	Structural Steel (such as A36)	Custom welded and cut	$20000	1
Cladding for Frame	Decorative Annodized Alumium Sheet (such as 5005)	Custom bent and formed	$10000	1
Table Frame	Structural Steel (such as A36)	Custom fabricated	$5000	1
Module Frame	Structural Steel (such as A36)	Custom welded and cut	$10000	1
Cladding for Module	Decorative Annodized Alumium Sheet (such as 5005)	Custom bent and formed with CNC milled elements	$10000	1
Module Visor	Polycarbonate	Vacuum formed	$5000	1
Module Roof	Polypropylene with faux wood vinyl	Vacuum formed	$500	1
Pickup Containers	Polycarbonate	Injection moulded	$8000	4
Solvent Tank	Glass with Silicone Caulking	Custom fabricated	$500	1
Curved Screen with Face Scanning Assembly			$10000	1
Camoflauging Visual Acuity Screen		Repurposed Samsung Frame style display	$500	1
Table Surface	Maple	Custom fabricated	$500	1
Chair Frame	Structural Steel (such as A36)	Custom fabricated	$1000	1
Chair Seat	Maple	Custom formed (possibly with hydralic press)	$300	1
Chair Foot Rest	Maple	Custom formed (possibly with hydralic press)	$100	1
Chair Back Rest	Maple	Custom formed (possibly with hydralic press)	$500	1
Blockers	Polycarbonate with smart glass film, tint, and steel frame	Drap formed and custom fabricated	$500	7
Base	Wood flooring over a steel frame	Custom fabricated	$10000	1

Component	Material	Manufacturing Process	Estimated Cost	Quantity
Functional Components				
Base Rails	A variety of metals		$10000	2
Testing Equipment			Varies by equipment	4
Robotic Arm Assemblies for Test Equipment	Plastic shell around metal components		$8000	4
Lights			$600	8
IDEX 3D Printer	ABS plastic		$1000	1
Lens Edging Machine				
Conveyor Belt	Rubber belt with metal components		$600	1
Assembly Robotic Arm	Plastic shell around metal components		$16000	1
Vending Robotic Arm	Plastic shell around metal components		$12000	1
Assembly Rail	Plastic shell around metal components		$4000	1
Vending Rail	Plastic shell around metal components		$1000	1
Pickup Box Rails	A variety of metals		$500	4
Base Motors for Chair	A variety of metals		$1000	1
Base Motors for Blocker	A variety of metals		$500	7
Kiosk Components				
Seat	Maple	Custom formed		1
Seat Cushion	Cotton with pillow stuffing	Upholstered		1
Top Stand	Maple	Custom formed (possibly using hydraulic press)		1
Bottom Stand	Structural Steel (such as A36)	Custom formed		1
Base	Maple	CNC cut		1
Screen Assembly + Camera				1
Joystick and Wrist Rest	ABS plastic	Injection Moulded		1

Component	Material	Manufacturing Process	Estimated Cost	Quantity
Assorted Components				
Fasteners	A variety of metals		$1000	
Mounting Brackets	A variety of metals		$1000	
Wiring Harnesses	A variety of polymers		$50	
Embedded Circuits			$300	
Computer Systems			$5000	
Wireless Adapter			$500	

Table 8 – Bill of Materials

5.3 Final CAD Rendering

Figure 64&65 – Insitu View of Booth in Crowed Area

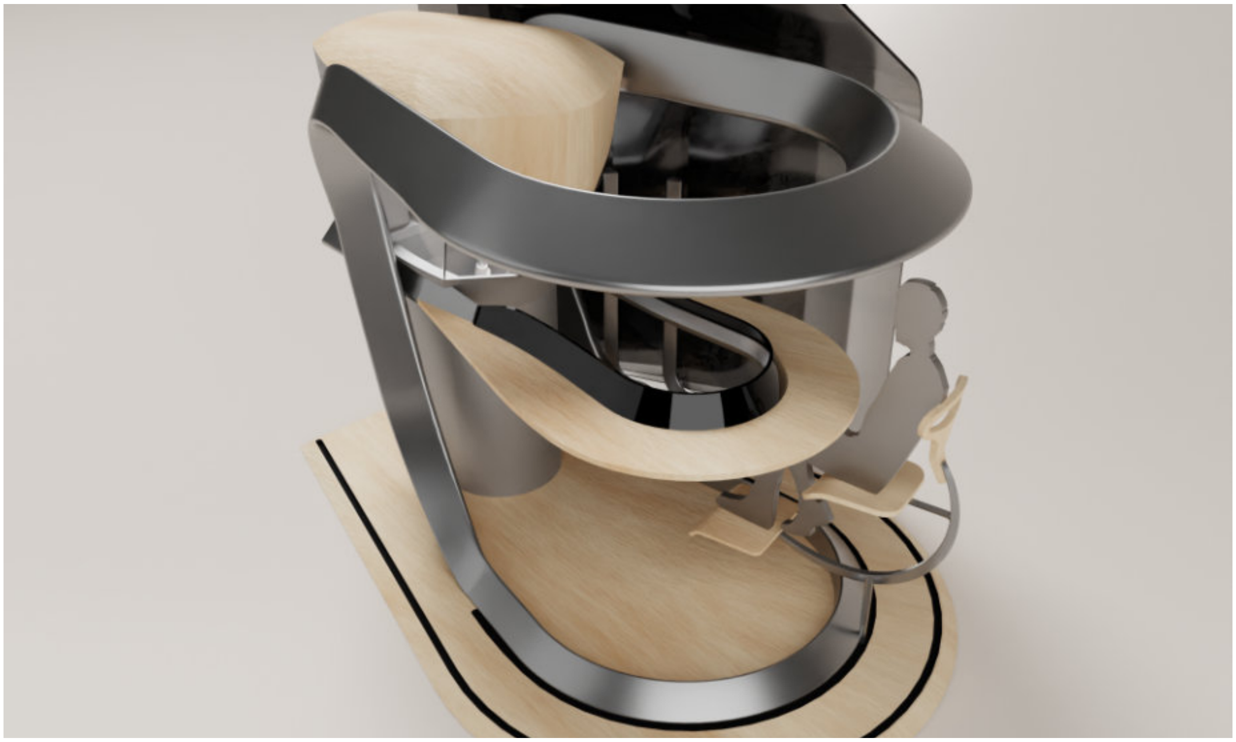


Figure 66 – View from Above of Booth

Figure 67 – Cutaway View

Figure 68 – View of Kiosk for Eye Health Professional

Figure 69 – View of Kiosk for Eye Health Professional

Figure 70 – View of Simulated Face Scan

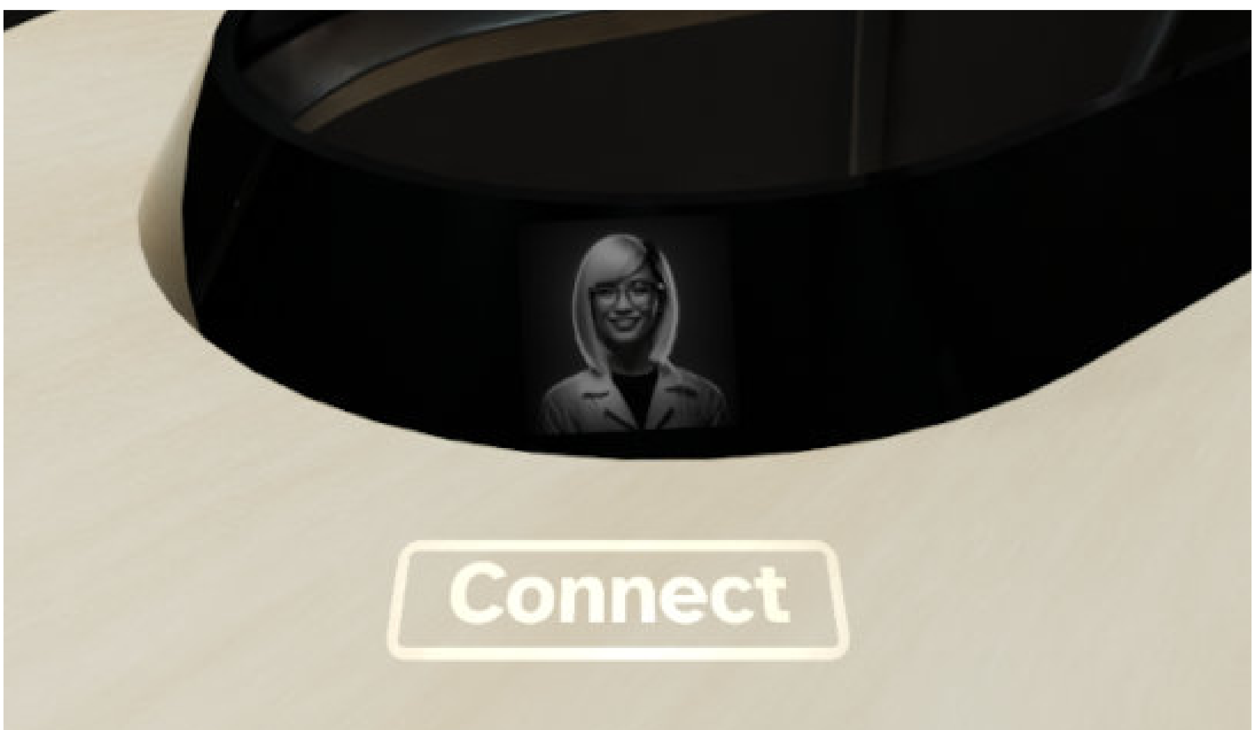


Figure 71 – UI of Booth During Connection

5.4 Physical Model

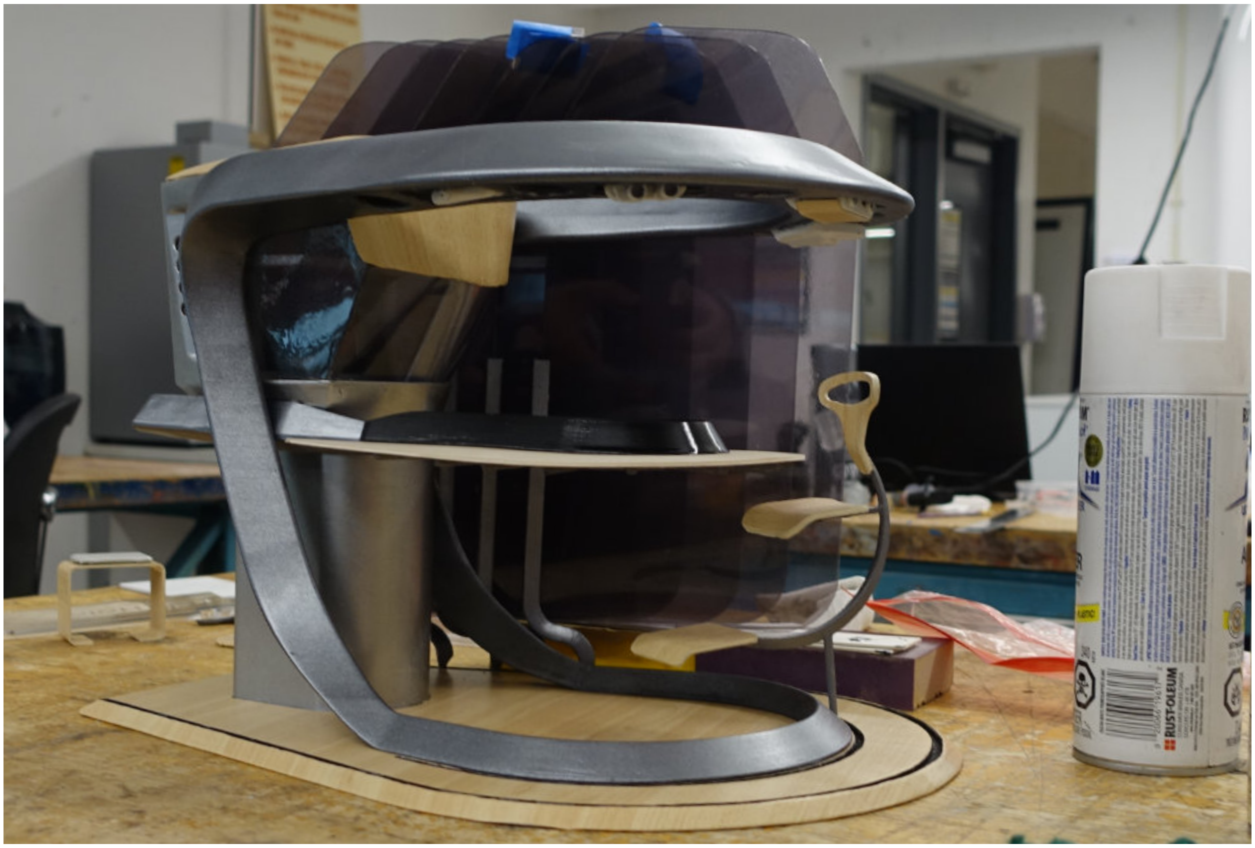


Figure 72 – View of Model

Figure 73 – Side View of Model

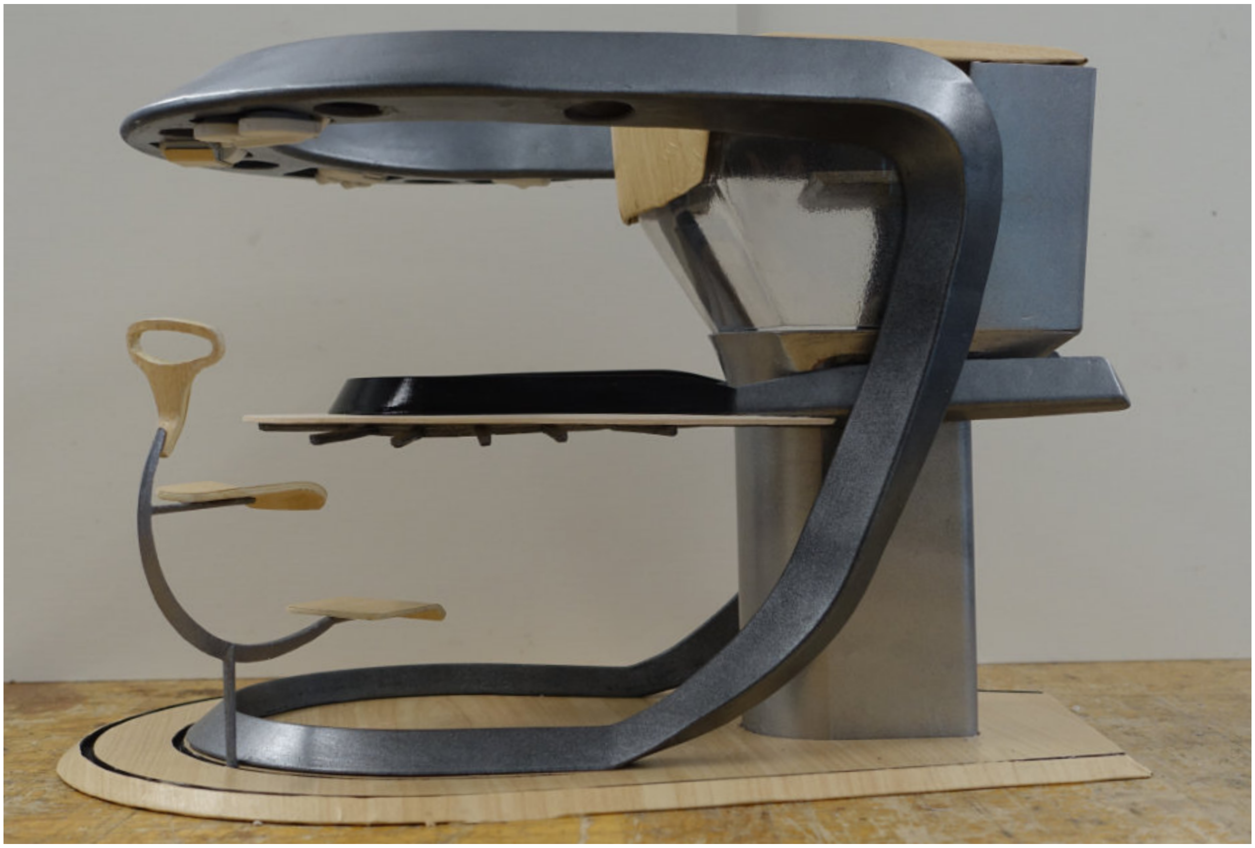


Figure 74 – Other Side View of Model


Figure 75 – Chair of Model

Figure 76 – Top of Model

Figure 77 – Front of Model

Figure 78 – Model with LEDs On


Figure 79 – Model with Kiosk

5.5 Technical Drawing

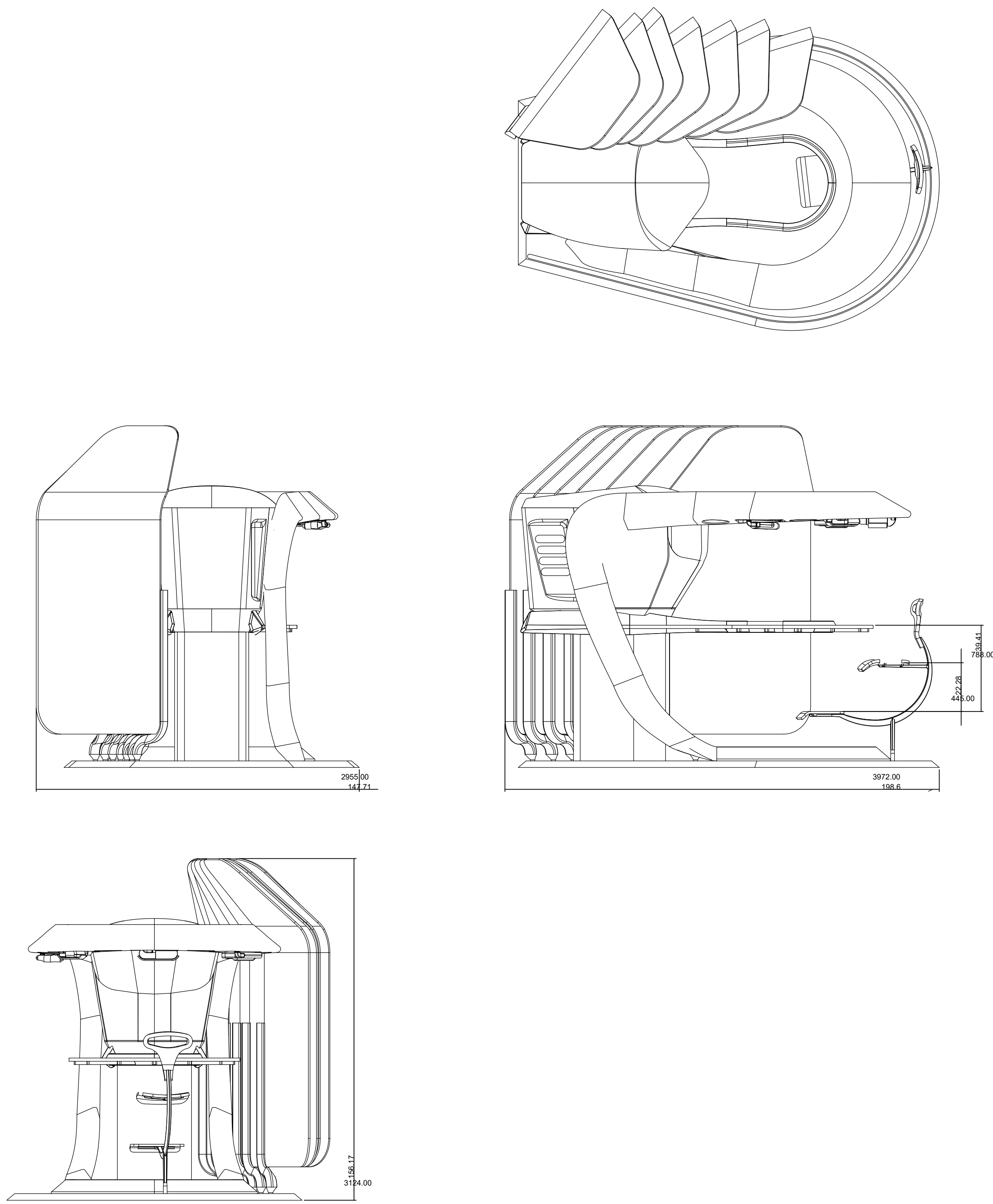


Figure 78 – Technical Drawing

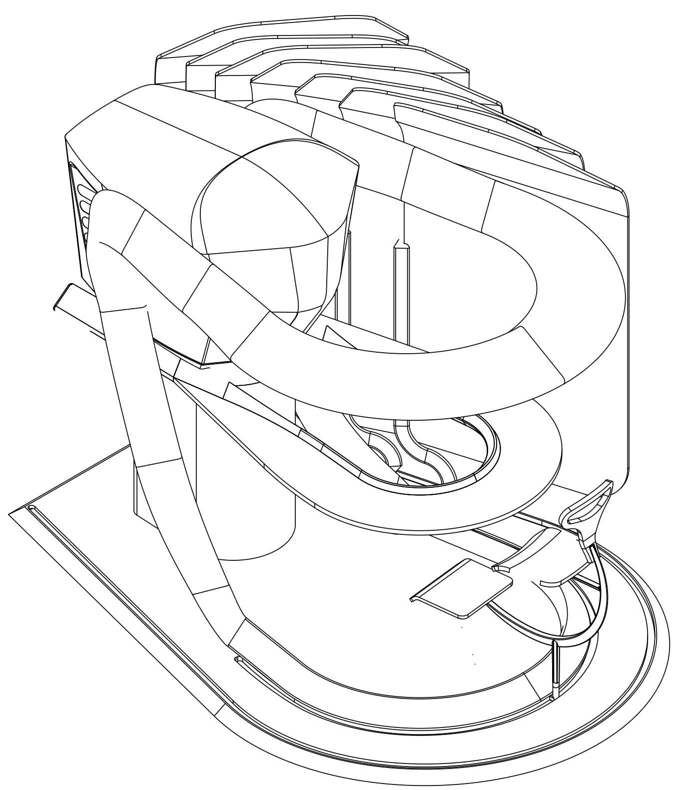


Figure 79 – Isometric Drawing

5.6 Sustainability

The overall sustainability of the solution is demonstrated by the concept's ability to reduce carbon emissions and through its use of materials. The ability for the vision care booth to be located in frequently travelled areas means that customers will not need to make an extra trip to receive vision care because they will likely be regularly visiting locations with a booth anyway. Having on-site manufacturing means that customers will also not need to make another trip just to pick up glasses. Finally, granting the ability for eye health providers to work from anywhere remotely also reducs to need to commute. Reducing the need to travel for users means that carbon emissions from vehicles would also be reduced.

The use of bioplastics in the frames of the glasses provides an opportunity for users to recycle the frames at the end of the product's life as many bioplastics are recyclable. Bioplastics are also renewable resources which provides better long-term availability for the material. Metals which are safely recyclable are used in the construction of the booth and kiosk. Steel and aluminum are both valuable and commonly used materials which are well known for being easy to recycle. The use of recyclable material prevents pollution.

CHAPTER 6 - Conclusion

To help improve accessibility to vision care services in lower income communities, Halo was developed. It is a tele-optometry system which seeks to create a viable business in providing users with affordable glasses and reliable vision care. By connecting customers to eye healthcare providers in a simple drop-in session and manufacturing custom personalized glasses. Through the convenience and affordability of these features, users are able to receive a better quality of life.

Halo’s fully guided experience creates for a simple and genuine interaction experience. The design and construction of the booth and kiosk was developed to use sustainable materials and each glasses frame is manufactured using renewable bioplastics.

By addressing the needs of users, creating a viable business, and promoting sustainable practices, Halo is able to provide a comprehensive solution to the lack of accessible vision care in lower income communities.

Additional Acknowledgements

A special acknowledgment to Tim who has made my four years studying more bearable by taking walks with me to the dam and staying in touch during the pandemics. I especially appreciate the late night finishing this very dossier where you held me between the delicate balance of falling asleep and losing my mind so I could get this done. I really appreciate all your help and company during my thesis. From helping me with all the problems I had during the modelling of the CAD to applying the wood grain vinyl on my model. It is rare to have a friend as caring and loyal as you are. I could not see myself in this program without you sticking with me for four years, thank you.

Another special acknowledgment to my cousin and good friend Newton who has always been a mentor to me in my career in design. I appreciate all the late nights you listened to my rants about anything, from buying a new computer during the pandemic to helping me decide between job opportunities. I appreciate your help in answering all the random questions I had and always being there for me. You have always been an inspiration and a role model to me.

Author’s Notes

I would like to grant a special thanks to all the previous dossiers that I have referenced in writing this dossier. To all the future graduates who read this dossier, I hope that I have made that experience memorable, inspiring, entertaining, and informative. It is always a pleasure to share the process of how this project came to fruition.

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Appendix A – Discovery

Inital research into the different problems related to the topic of providing vision care to remote communities.

Article 1: Effect of providing free glasses on children's educational outcomes in China: cluster randomized controlled trial

Ma, X., Zhou, Z., Yi, H., Pang, X., Shi, Y., Chen, Q., Meltzer, M. E., le Cessie, S., He, M., Rozelle, S., Liu, Y., & Congdon, N. (2014). Effect of providing free glasses on children's educational outcomes in China: cluster randomized controlled trial. *BMJ : British Medical Journal (Online), 349*https://doi.org/10.1136/bmj.g5740

Summary Statements

- Receiving access to eyeglasses have the potential to improve an individual’s ability to be productive
- Rural communities often have the most difficult time getting access to eyeglasses
- Eyeglasses tend to be expensive to the individual but if purchased in bulk by a public institution, it is quite affordable
- Receiving access to eyeglasses can help students study and learn more effectively
- Encouraging use of spectacles and overcoming myths about wear eyeglasses are a factor in overcoming challenges related to vision correction
- Myopia is a very common affliction in young children in China
- Eyeglasses are usually the most common, safe, and inexpensive method of treating myopia
- Classrooms that prefer certain teaching devices like blackboards may disadvantage certain students who require vision correction
- Eyeglasses tend to be extremely expensive for rural families

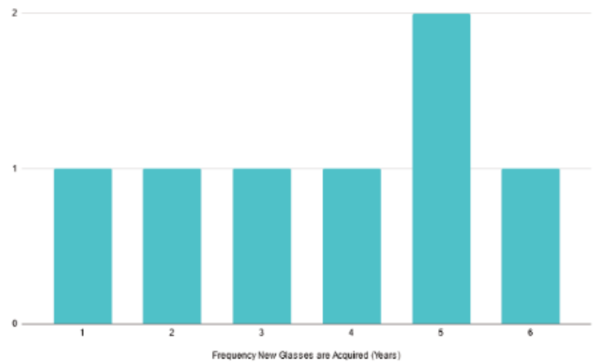
Article 2: Challenges, Attitudes and Practices of the Spectacle Wearers in a Resource-Limited Economy

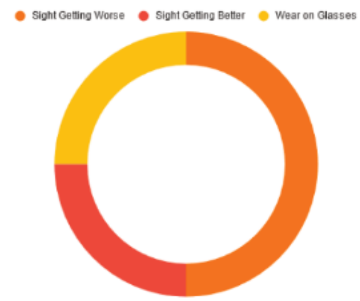
Ayanniyi, A. A., Adepoju, F. G., Ayanniyi, R. O., & Morgan, R. E. (2010). Challenges, attitudes and practices of the spectacle wearers in a resource-limited economy. *Middle East African journal of ophthalmology*, *17*(1), 83–87. https://doi.org/10.4103/0974-9233.61223 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2880380/

Summary Statements

- Damaged and improper use of eyeglasses could be caused by lack of education in how to care of eyeglasses
- Certain age groups and people working in certain careers had a great need for eyeglasses when compared to others
- People wear glasses for clear vision and to be able to read
- Visual impairment that can easily be remedied by eyeglasses is a global health burden
- Unprofessional roadside dispensers of glasses are attractive to low income customers because of their reduced prices
- There are still widespread myths about how eyeglasses can be dangerous
- Technicians with less training but with basic skills can provide more widespread coverage for basic ailments
- Eyewear is too expensive, and the prices need to be regulated

Appendix B – Contextual Research (User)





Participants get new glasses every **1-6** years,

Participants get new glasses based on **need.**

1 Participants usually keep pair of spare glasses, which usually are their previous pair.

Design and colour
Is the main way participants choose between frames.

Affordability
Is the main challenge restricting users from accessing services

Generally easy
Is how participants describe their experience accessing eyecare services

Summary: How this may inform design

- Participants generally change glasses infrequently and only if they need to
- Access to eyewear was generally limited by its affordability
- Spare glasses are not very common and usually take the form of old glasses

Excerpt from Interview

Q What do you think of the style trends of eyeglasses? What about buying glasses for fashion?

A Not necessary trends, just whatever works well on my face. I don’t really care about what is popular. I look to see if the colour

matches my hair and my face.

Q What issues do you commonly have with eyeglasses and the processes of acquiring eyeglasses?

A Finding something I like the look of and is affordable. Often the nicest frames are the most expensive. It is usually between the

style and the cost.

Q How difficult is it for you to access eyeglasses services?

A It depends, the optometrist I see is in (redacted). It may be different here(in Toronto). If I can just get another optometrist, I

would just go somewhere nearby. The process is pretty simple, I just go to get my eyes tested, get the prescription, take the

prescription to the place where you buy glasses, usually nearby the optometrist so you can just buy them there. A lot of the

optometrists don't have a huge variety of frames so if you want a specific brand or style, you need to hunt around for it. Once you

find the frame you want, you get to give them your prescription.

Q What would you like to change in the glasses industry currently?

A I think that getting your eyes tested should be free because it costs a decent amount. With the health care system, I am not very

familiar with it, but I think it should be free. It costs like $50-80 bucks I think .

Summary: How this may inform design

- Style of the frames and glasses are quite important but not necessarily because of current trends

- There are little issues navigating the process for acquiring new glasses

- Vision care services are too expensive and should be covered as a public health services

- Cost is a major factor with getting new glasses

Appendix C – Approval Forms & Plans

IDSN 4502
SENIOR LEVEL THESIS TWO

Humber ITAL / Faculty of Applied Sciences & Technology
Bachelor of Industrial Design / WINTER 2023
Catherine Chong / Fredric Matovu

CRITICAL MILESTONES: APPROVAL FOR CAD DEVELOPMENT & MODEL FABRICATION

Student Name:	Justin Ho
Approved Thesis Title:	Improving Access to Vision Care

THESIS PROJECT – DESIGN APPROVAL FORM

Design is reviewed and approved to proceed for the following:	X **CAD Design and Development Phase**
Comment:	Continue design refinement in CAD development, need to iron out detailing and product's features, pay attention to surfacing, components, and assembly methods for design feasibility. Viable holistic design thinking in conjunction with considerations into sustainability aspects. CAD development must be at least 75% complete for review before approval for fabrication.

Design is reviewed and approved to proceed for the following:	X **Model Fabrication Including Rapid Prototyping / 3D Printing and Model Building Phase**
Comment:	Waiting for CAD development review (as of Feb-21). CAD progress well, design completed, continue detail refinement, once refined, fabrication of model can begin.

Instructor Signature(s):	Catherine Chong F.K. Matovu
Date:	07 March 023

PANEL ON RESEARCH ETHICS
Navigating the ethics of human research

TCPS 2: CORE 2022

Certificate of Completion

This document certifies that

Justin Ho

successfully completed the Course on Research Ethics based on the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS 2: CORE 2022)

Certificate # 0000838819

5 September, 2022

Propose Topics

Task	Person	Status	Date
Brainstorm 3 potential thesis topics	JH		Jul 1
Brainstorm an additional 3 thesis topics (to have 6 in total)	JH		Aug 1
Compete brief research and fill out information on each topic idea	JH		Sep 2
Define problem definition and justify each topic	JH		Sep 13
Complete TCPS research ethics course	JH		Sep 5
Complete User, Product, and Environment of Use Triangulation	JH		Sep 27
Finish topic proposals	JH		Oct 4
+ Add Task			

Reach out to advisors

Task	Person	Status	Date
Message staff	JH	Working on it	Oct 11
Contact local businesses that offer free dental services to elementary schooles	JH	Working on it	Oct 11
Reach out to advisors	JH	Working on it	Oct 11
Dial 311 and discover local services	JH	Working on it	Oct 11
Visit headquarters	JH	Working on it	Oct 14
Have out the advisor document	JH		Oct 14
Complete meetings/email with dental health providers to elementary schools	JH		Oct 18
Complete meetings/emails with optometrists	JH		Oct 18
Finish advisor outreach	JH		Nov 1
+ Add Task			

Start Ideations

Task	Person	Status	Date
Start ideations	JH		Oct 18
Brainstorm initial ideas in thumbnails and roughly	JH		Oct 18
Touch up ideas and present them as individual concepts	JH		Oct 25
Finish ideations	JH		Nov 1
+ Add Task			

Concept Exploration

Task	Person	Status	Date
Start concept exploration	JH		Nov 1
Finish concept exploration	JH		Nov 8
Start mind mapping of concepts	JH		Nov 3
Evaluate different approaches of ideas, pros and cons	JH		Nov 3
Look at inspiration and trends for ideas	JH		Nov 3
Complete more sketches based on ideas	JH		Nov 7
+ Add Task			

Selected Concept Strategy and Product Schematic

Task	Person	Status	Date
Start concept strategy and product schematic	JH		Nov 8
Finish concept strategy and product schematic	JH		Nov 22
Look at usability and functions	JH		Nov 11
Look at how existing products handle human factors	JH		Nov 11
Make diagram of key ergonomic points	JH		Nov 15
Make physical model of design	JH		Nov 15
Acquire materials for physical model	JH		Nov 12
+ Add Task			

Human Factors

Task	Person	Status	Date
Start human factors study	JH		Nov 22
Finish human factor analysis	JH		Dec 5
Complete user observation study	JH		Nov 24
Analyze the ergonomic usability and function	JH		Nov 25
Analyze touch points	JH		Nov 26
Create diagram of ergonomics	JH		Nov 28
Contact advisor for user observational study	JH		Nov 28
Complete final diagram of ergonomics	JH		Dec 2
Make final presentation of progress with ergonomics and solution	JH		Dec 5
+ Add Task			

Thesis Dossier

Task	Person	Status	Date
Thesis Dossier chapter 1	JH		Dec 6
Thesis Dossier chapter 2	JH		Dec 6
Thesis Dossier chapter 3	JH		Dec 6

Appendix D –Advisor Meetings & Agreement Forms

HUMBER
Faculty of Applied Sciences & Technology

IDSN 4002 /4502

Bachelor of Industrial Design / FALL 2022 &

PARTICIPANT INFORMED CONSENT FORM

Research Study Topic: How may we improve vision correction services to lower income communities?

Investigator: [redacted]

Courses: IDSN 4002 & IDSN 4502 Senior Level Thesis One & Two

I, [redacted] *(First Name/Last Name)*, have carefully read the Information Letter for the project on improving accessibility to eyecare services in low income communities, led by Justin Ho. A member of the research team has explained the project to me and has answered all of my questions about it. I understand that if I have additional questions about the project, I can contact Justin Ho at any time during the project.

I understand that my participation is voluntary and give my consent freely in voice recording, photography and/or videotaping; with the proviso that my identity will be blurred in reports and publications.

Consent for Publication:	Add a (X) mark in one of the columns for each activity	YES	NO
ACTIVITY Publication	I give consent for publication in the Humber Library Digital Repository which is an open access portal available to the public	☒	☐
Review	I give consent for review by the Professor	☒	☐

Privacy

All data gathered is stored anonymously and kept confidential. Only the principle investigator researcher, Justin Ho and Prof. Catherine Chong or Prof. Frederick Matovu may access and analyze the data. All published data will be coded, so that visual data is not identifiable. Pseudonyms will be used to quote a participant and data would be aggregated.

I also understand that I may decline or withdraw from participation at any time, without negative consequences.

I understand that I can verify the ethical approval of this study, or raise any concerns I may have by contacting the Humber Research Ethics Board, Dr. Lydia Boyko, REB Chair, 416-675-6622 ext. 79322, **Lydia.Boyko@humber.ca** or « insert student Name /Phone Number /Email Address ».

Verification of having read the Informed Consent Form:

☒ I have read the Informed Consent Form.

My signature below verifies that I have read this document and give consent to the use of the data from questionnaires and interviews in research report, publications (if any) and presentations with the proviso that my identity will not be disclosed. I have received a copy of the Information Letter, and that I agree to participate in the research project as it has been described in the Information Letter.

Participant's Name	Participant's Signature	Date
[redacted]	[redacted]	[redacted]

3

IDSN 4002 /4502

HUMBER
Faculty of Applied Sciences & Technology
Bachelor of Industrial Design / FALL 2022 &

INFORMATION LETTER

Conditions of Participation

- ✓ I understand that I am free to withdraw from the study at any time without any consequences.
- ✓ I understand that my participation in this study is confidential. (i.e. the researcher will know but will not disclose my identity)
- ✓ My identity will be masked.
- ✓ I understand that the data from this study may be published.

☒ **I have read the information presented above and I understand this agreement. I voluntarily agree to take part in this study.**

[redacted] Participant's Name | [redacted] Participant's Signature | [redacted] Date

Project Information

Thank you very much for your time and help in making this study possible. If you have any queries or wish to know more about this Senior Level Thesis project, please contact me at the followings:

Phone: [redacted]

Email:

My supervisor is:

Prof. Catherine Chong, **catherine.chong@humber.ca**

2

IDSN 4002 /4502

INFORMATION LETTER

Conditions of Participation

- ✓ I understand that I am free to withdraw from the study at any time without any consequences.
- ✓ I understand that my participation in this study is confidential. (i.e. the researcher will know but will not disclose my identity)
- ✓ My identity will be masked.
- ✓ I understand that the data from this study may be published.

☑ **I have read the information prese[redacted]reement. I voluntarily agree to take part in this study.**

[redacted]

Participant's Name [redacted] Date

Project Information

Thank you very much for your time and help in making this study possible. If you have any queries or wish to know more about this Senior Level Thesis project, please contact me at the followings:

Phone: [redacted]

Email: [redacted]

My supervisor is:

Prof. Catherine Chong, **catherine.chong@humber.ca**

IDSN 4002 /4502

HUMBER
Faculty of Applied Sciences & Technology
Bachelor of Industrial Design / FALL 2022 &

PARTICIPANT INFORMED CONSENT FORM

Research Study Topic: How may we improve vision correction services to lower income communities?

Investigator: [redacted]

Courses: [redacted] IDSN 4002 & IDSN 4502 Senior Level Thesis One & Two

I, [redacted] _(First Name/Last Name)_, have carefully read the Inf[redacted] improving accessibility to eyecare services in low income communities, led by Justin Ho. A member of the research team has explained the project to me and has answered all of my questions about it. I understand that if I have additional questions about the project, I can contact Justin Ho at any time during the project.

I understand that my participation is voluntary and give my consent freely in voice recording, photography and/or videotaping; with the proviso that my identity will be blurred in reports and publications.

Consent for Publication:	Add a (X) mark in one of the columns for each activity	YES	NO
ACTIVITY Publication	I give consent for publication in the Humber Library Digital Repository which is an open access portal available to the public	☑	☐
Review	I give consent for review by the Professor	☑	☐

Privacy

All data gathered is stored anonymously and kept confidential. Only the principle investigator researcher, Justin Ho and Prof. Catherine Chong or Prof. Frederick Matovu may access and analyze the data. All published data will be coded, so that visual data is not identifiable. Pseudonyms will be used to quote a participant and data would be aggregated.

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Verification of having read the Informed Consent Form:

☑ I have read the Informed Consent Form.

My signature below verifies that I have re[redacted]se of the data from questionnaires and interviews in research report, public[redacted]roviso that my identity will not be disclosed. I have received a copy of the[redacted]cipate in the research project as it has been described in the Information Le[redacted]

[redacted]

Participant's Name

[redacted]

Rough Notes of Interview with :

Please introduce yourself and your role working

Bartending at the hotel for 21 years and while studing. A guy from hakim optical and talk to you at the bar. We worked to put some cash together and opening a store and it costs a lot of operate a store. Let's put it in a bus and sell hot dogs. Native communities don't care if it is a store or not, they only care about the glasses. If you do it i will help you. They ask how much a bus to lease is a month. It is cheap to start the business but the guy from hakim optical said if you need doctors or glasses, I can help.

My wife was not an optician at the point, she was senior marketing management with masters at york. Was senior marketing management at GE making more than $100,000.

you don't need a bus, you need a truck with a trailer because a bus needs to wait 1 or two months to change oil and fix. There is always going to be a pickup truck around the corner ready to be rented.

Started at conestoga college doing eye exams.

What type of equipment did you choose to include in the vehicle and why? What type of medical professionals and staff are at each of your mobile clinic facilities? (optometrists and eye exams vs opticians and glasses adjustments)

a manager and operations technicians, optometrists, and optician.   Every time a reserve is visited, around 20 people a day. Normal stores sees 6 or 7 people a day.

Autorefractor saves lots of money, it is able to instantly take a reading for the perscription.

lens meter to test existing lenses

phoroptor, tests the different lenes

slip lamp looks at the back of the eyes

docots lens kit which has all

stigmatism is geometry of the eye and that it has changed. Usually online eye services are not able to diagnose.

Non-contact tonometer is used to measure the pressure of the eye (intraoculor pressue.. They used to use a needle to to push the eye but now they use a little device that blows air into the eye. The pressure of the eye is important to determine the firmness. High eye pressure causes glaucoma and low eye pressure causes other eye problems.

***What type of problems typically arise from people trying to receive vision care services and eyeglasses services. How did the design address those issues?

It sells convenience.

***What kind of issues to eye glasses providers run into when working?

***What are the limitations? What things would you look to change about it? What about scalability?

The scalability is always in the problem. I would rather be the middle man than the one who handles the customers. It takes money, the problem is teaching people and i had two people but they all left. I would always want to do it . Canada is too conservative with businesses they not willing to try new things. I want to to franchise to immigrants who are husband and wife and in the backyard they park the trailer. The goal is to sell the trailer, that is the exit plan to all the big companies to buy out startups. Mobile optics just give glasses and expect a perscription.

To goal is to have blueprints and a factory. Every august and january, we close and there is not good business. The worry is investing in people.

***What type of trends do you see in the future of eyewear and what role do you think technology will play in the future of eyewear?

The camera glasses are bullshit, you can listen to music, there is too much corporate, with the glasses, it is not it.

Trends come in go, trends in glasses from the 70s are coming back, famous celebrities wear glasses, it goes on back order.

Trends are not worth anything, the sellers from the glasses companies will let you know what is good. The relationship between the sellers are good, if they screw you over you can go back to ask them wtf, there will work.

Scanners in the future may be able to scan your eyes and see if things fit or not, and they will make a custom glasses to fit you. This is very industrial design but i haven't looked much into it.

wife is the planner, husband is more on the fly. At the end it works out.

Online glasses for single vision, it works, when it comes to progressive glasses, it is really hard to get a proper glasses online. What we do has a future, you need to know someone who knows what there doing. You see one thing and youget another.
Some universal fit glasses need some extra fit and spacers.

8ft wide special license to drive

***What role do brand names eyeglasses and style trends play into how your business operates?

Some native communities are not able to afford glasses so they are usually not getting the top trends but this type of trailer is able to reach both business and normal customers so they can easily swap the different frame styles quickly by having a modular trailer system.

Always ready to work with their coverage, you can make frames under $150, but the quality is bad. Under $250, the lenses may be a bit more simple. People are usually happy to pay a bit more because the glasses need to take longer. Natives pay cash and people use credit cards.

Aya first nations glasses

works with representative, for the brands, they have brand representatives

***You mentioned that you visit many low income communities like native reserves, what other types of communities do you visit and which ones would you like to visit but are not able to?

You get calls from the mountains of british columbia, thunder bay, timins, nurcing homes, can be busy all day. Some communities will never be profitable. Elementary schools and community centers there is a lot of conern with consent from parents and liability from parents. At the end it is for profit. It is too difficult.

***How long does it take to prepare the trailer for the road?

There is a generator but a power plug would be nice as well. If it too hot or too cold, the plug in the buiding is nto enough. The generator gives 30 a form ac and printer. The generator needs to be in the front of the trailer for better balance. When you park, you need to level the trailer or else it will rock. You need lifters to raise and lower the trailer, rlift it about 2-3 inches. It is like a building.

45 mins to fill in the trailer, or even 30 mins, do it the night before. Come int he morning and there is a check list of all the things that are needs is done. Sometime we go and setup indoors without the trailer. Slit lamp
non contactonometer

sometimes you need pipes and draps to divide the room off, sometimes there is no parking, we can make it happen without the parking . Two carts and go into an offic and set up everything . One hour to setup and 45 minutes to take down . Some people don,t want to go downstairs and get glasses on a snowy day . We make a portable store. Go through the checklist to get. We don't need to have the equipment in the trailer permanently, it is about 65,000 for even just the cheapest equipment. We are talking to have a doctor to setupt their stuff at the store and keep the equipment in the trailer. To setup a doctors office here is qutie expensive.

***How does your business function to both be profitable and offer services to low income communities?

They are able to reach more customers and they are able to take advantage of subsides by the government. The government gives $250 for natives to get glasses.

*** what is the typical process of a new customer getting their eye tests and getting glasses?

Usually the get their eyes tested, depending on the results, they get refered to a specialist or orders a pair of glasses.

*** Why do you choose to have both a physical store and a mobile care service?

Some times customers are referred to the local store who are nearby. The local store is also often open on the weekend when the trailer is not being operated.

I appreciate your time and flexibility helping me with this project.