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Executive Summary

Problem

As a result of the COVID-19 pandemic, masks are in short supply in the market--surgical masks and N95 respirators are reserved only for healthcare professionals. The general public has few effective options in protecting themselves or preventing the spread of the coronavirus.

Purpose and Requirements

Our team sought to develop a mask that is comfortable, breathable, effective, and implementable at home. Specifically, ensuring that the mask can be made at home also requires that it be cost-effective and easy to build.

Methodology

In addition to conducting independent research about current DIY masks, we developed five mockups to better understand advantages and disadvantages of different design options. These mockups underwent extensive user and performance testing to ensure effectiveness in filtration. After conducting our design review, we leveraged the feedback we received from reviewers to further improve our design.

Design

The CATWOT (Comfortable Alternative to What's out There) is a DIY mask that shields the user from airborne, viral particles. It has an inner layer that provides comfort and alleviates skin irritation; an outer layer that traps the majority of small, viral particles; a connecting frame that pieces the two layers together; and elastic bands with loops to stretch around the user's head to create a seal. The (INSERT MASK NAME) begins to satisfy four needs that are only met partially in existing products:

- Comfort: Elastic bands wrap around the head rather than provide pressure upon the ears. The inner layer provides a soft cushion.
- Breathability: The CATWOT is made from materials with high breathability scores according to performance testing and secondary research.
- Effectiveness: Performance testing along with research indicate that our mask blocks out the majority of particles carrying the virus.
- Ability to be made at Home: The CATWOT was specifically designed with common household goods in mind. All materials are easy to locate and cost-effective. Additionally, the mask can be built in less than an hour.

Introduction

Thanks to the recent COVID-19 pandemic that has impacted all of our lives, we have realized the importances of masks in reducing the spread of viruses. However, this realization came with an extreme shortage of masks. Our project aims to combat this shortage of masks by releasing an easy DIY mask made of materials easily accessible at home.

There are many DIY solutions currently on the market with the T-shirt mask being one of the most popular. The problem with these solutions is that they don't provide the same safety as a surgical mask. We want to design a mask that falls somewhere on the spectrum between a surgical mask and a n95 respirator.

Our mask is called The CATWOT (The Comfortable Alternative to What's out There) . It brings together a pillow case, wire, elastic bands, and foot insoles as new materials for a mask. The pillow case will be turned into the body of the mask and the elastic bands will be the straps of the mask to connect it to the user's head. The wire will be used to help mold the mask into the user's face so the fit will be tighter and will be surrounded by a cushioning material which would be cut up foot-insole materials.

This report will detail the design process for our mask and will include construction instructions for the design as well as instructions for use. The following sections will introduce the potential users for this mask and what our design was aiming to focus on, how and why we designed the mask to fit those requirements we focused on, and future developments for this project.

Users and Requirements

Users

Demographic

***An ordinary person running errands*.** The main users include anyone leaving their home during the coronavirus pandemic to go to the grocery store or perform other errands in highly populated areas. These users may want an easily accessible means of protection that offers more than a t-shirt or bandana wrapped around their mouth.

***An essential worker*.** This user sub-group excludes healthcare professionals that may require more advanced equipment than we can provide. Essential workers such as grocery or postal workers are not always supplied with proper protective gear. They come into direct and indirect contact with dozens of people every day and are at higher risk than most for contracting the virus or carrying it home to family members.

Example User Profile

> *Rosa is a thirty-five year-old single mother living at home with her two children. Due to the pandemic, she is working from home and is also taking care of her children because they can no longer go to school. Rosa knows that she needs to go out to buy groceries at some point since her family is running low on food, but she is worried about potentially exposing her family to the virus if someone at the store is sick. So, she decides that in order to keep her and her family safe she must wear some protective equipment, namely, a face mask. However, Rosa cannot afford to buy a fancy mask and she doesn't have the time or equipment necessary to make a home-sewn mask herself. Rosa mulls over her options online but is becoming increasingly worried that there isn't anything out there she can make that will keep her and her family safe.*

Requirements

During the research process our team identified a list of specific requirements that the final design must meet in order to be effective. These requirements deal both with user accessibility since the project is meant to be a model DIY project, and functionality (Appendix C).

***Easy At-Home Implementation*.** To make a more high-performing substitute for a t-shirt or bandana mask, the design must be made from materials found in a common household. Users will be more inclined to adopt our design over a simpler one if they can access its materials with minimal effort.

***Comfort and Breathability*.** Users will not adopt this design if it is not comfortable to wear, so the mask should be cushioned for comfort. The mask must also be breathable and comfortable for the user, especially since the user may wear the mask routinely.

***Effective Protection*.** To be more effective than a common t-shirt or bandana mask, our design must be as tightly sealed as possible without significantly compromising breathability. A balance

between comfort, breathability, and effectiveness in protecting the user from the virus will be achieved through different materials to maximize the likelihood of use.

Design Concept and Rationale

The CATWOT is a DIY mask that shields the user from airborne particles in the current COVID-19 pandemic. In addition to the physical prototype, our design concept includes a detailed set of instructions for construction in order to provide a way for users to create the mask.

In terms of design, the CATWOT is composed of three main elements: the mask filter, the inner layers, and the straps. The filter material is made from a pillowcase and makes up the main body of the mask. Pillowcase fabric is a material which has both good properties in terms of breathability and filtering out airborne particles. The first section of the inner layer is composed of a paper clip frame which acts as a moldable support-material so that the user can make a better seal on their face. The second section of the inner layer is composed of material salvaged from an old shoe insole. This layer is intended to act as a barrier between the user's face and the paperclip. It also acts to provide a better seal. Four elastic bands connect to the mask that create loops to stretch around the user's head to fix the mask to the face seal.

During our research on the available options for a DIY mask, we found that while there were a multitude of different good options to choose from, there was not a single design that stood out in terms of achieving everything we saw necessary. Because of this, in creating a design concept for a DIY mask, we took inspiration from products that are already out there - including ones we tested - and implemented them into one cohesive design concept. While the design concept has elements similar to those found in comparable alternatives, there are a few key design choices that make our maks stand out. First, the pillowcase material is something not found in any of the masks we looked at during our research. Most of these masks use fabric from clothes or fabric intended for sewing, so the pillowcase material provides novelty in that sense. Second, the layer system we implemented is completely novel. None of the alternatives we looked into utilized anything similar to what we produced for the design concept. So in this case, the use of a paperclip as a supporting frame and the use of a shoe insole as a buffer material is completely novel.

The following sections describe the components of the device -- the pillowcase, attached straps, a foot insole, and a frame -- as well as the rationale behind each component.

Pillow Case Covering

Component Description

Cloth from a household pillowcase makes up the outermost layer of the mask, forming the mask's main protection against the coronavirus. The type of pillowcase we strongly recommend is one made from 200 thread count fabric. Simply put, pillowcases with the *least* thread count are preferable because they allow for greater breathability. Avoid high thread count pillowcases at all costs. The pillowcase cover is cut in the shape of a rectangle, with rounded edges. The dimensions of the cut rectangle are X LENGTH by Y LENGTH, but can vary depending on facial size. It weighs approximately 2 ounces.

Rationale

In conducting our research, we discovered that pillowcase material performs well in both breathability and filtering.

We made sure to test that filtration firsthand through performance testing. The flame test, one of our main metrics to determine filtration, consists of attempting to blow out a candle flame through the mask from different distances and thus identifying the airflow of the mask. A mask passes the flame test if users are unable to blow out the flame; ideally, the flame must only waver, if it moves at all. Performance testing indicated that a bunched up cotton t-shirt sleeve passed the flame test. With a lower count pillowcase, the covering should similarly pass that test.

Not only are pillowcases effective in filtering the particles responsible for the coronavirus, but they are also relatively cost-effective and common. Since one of our self-imposed criteria consisted of having a high implementability at home, we sought common household goods and settled on the pillowcase. Alternatives included t-shirts, which we felt were too thin, and bedsheets, which we realized were not as common as we initially thought after user feedback.

Finally, the dimensions of the mask filter were chosen to accommodate as many people as possible while still being effective. While our team did not create multiple prototypes to accommodate for different face sizes, we did take this development into account. The design and dimensions of the prototype should fit the average adult person, however, the design is not intended for use for children.

Attached Straps

Component Description

The mask will be attached to the user's head using two pairs of horizontal straps that loop around the back of the head.

The pillowcase's corners tied to the hair ties. Between the folds are four elastic hair bands, one attached at each corner. A strip of fabric, either additional pillowcase or cotton, is then tied around each pair of holes to form a closed loop. The hair ties stretch behind the head to create a tight seal. These hair ties collectively weigh X OUNCES.

(INSERT VISUAL HERE)

Rationale

We explored two distinct options when considering the placement of the straps. They could either attach behind the ears or behind the head of the user. Our Sock Mask mockup indicated, however, that attaching behind the ears placed immense pressure upon the user and led to general discomfort. Since one of our main design criteria is comfort, we decided to move forward with the other option: attaching the straps behind the head. Attaching the mask behind the ears may have made a tighter seal but sacrificed comfort. Attaching behind the head maintains tight sealing as well as comfort.The attachmentn method was also considered and tying the elastic bands to the mask was chosen due to simplicity.

After listening to feedback at the Design Review with a professional from the Segal Shop, Northwestern Design Thinking and Communication professors, and other McCormick Engineering peers, we noted that the majority of people did not want to spend time learning to sew in order to construct their mask (Appendix J: Design Review Summary). Instead, they

wanted a simple design that would not take too long to build. We used hair bands as the material because they attach well, as our Coffee Filter Mockup indicated, but did not incorporate sewing as part of our process.

Foot Insole

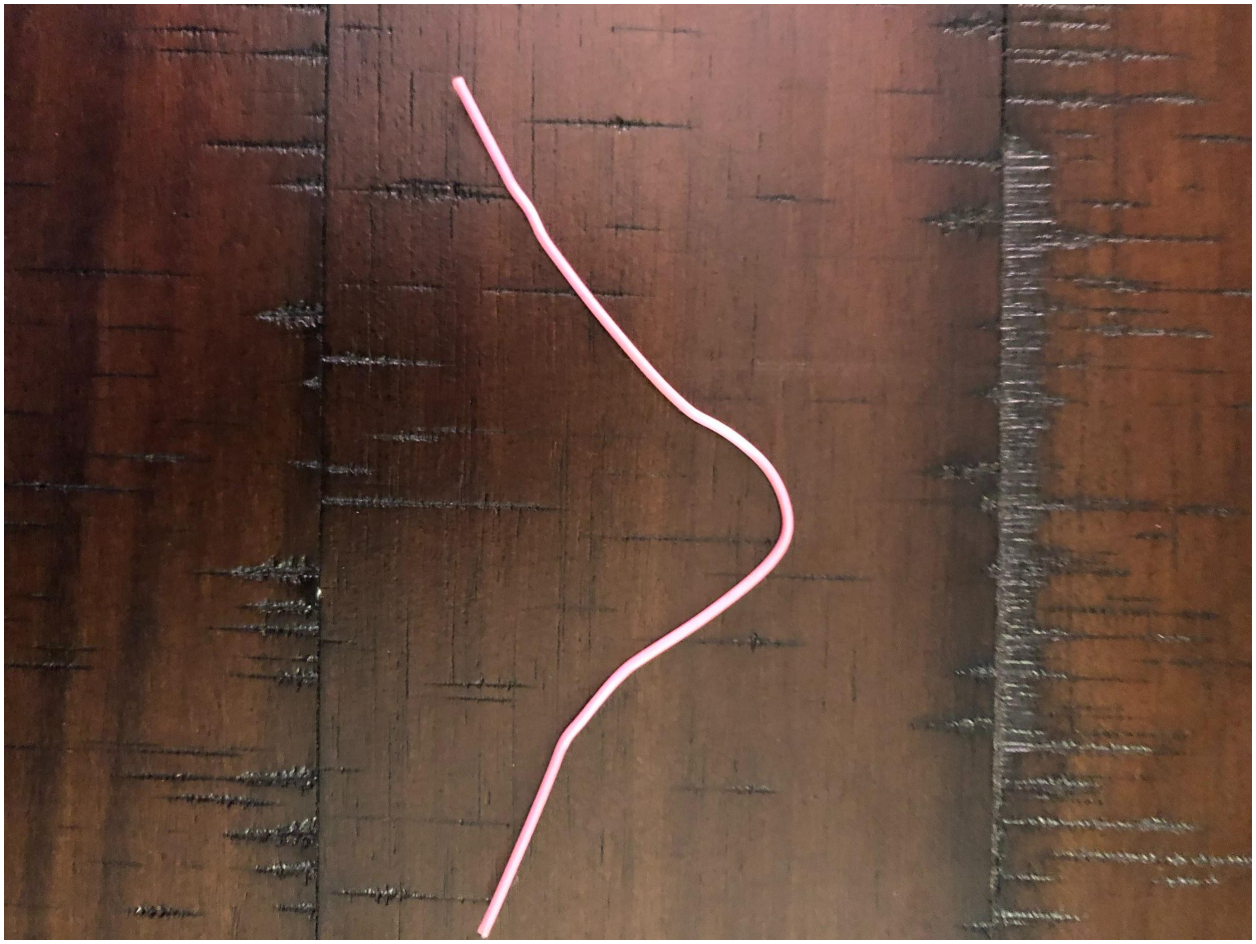
Component Description

The foot insole provides a soft cushion for the face. The gel material may also function as a cooling agent. Gel insoles can be purchased from common stores like Target or WalMart and are also available through online vendors such as Amazon. One insole is approximately five inches by half of an inch.

Rationale

Our background research indicated that when people wore masks for extended periods of time, their skin would become irritated (Appendix A: Preliminary Research). This issue can be seen especially in the cases of healthcare workers. To alleviate skin irritation, we sought out a common household good that is soft and comfortable. An alternative suggested by the Northwestern Design Thinking and Communication professors included ski goggles, which we felt were potentially inaccessible and expensive for the general public.

Paper Clip Frame



Component Description

The paper clip frame runs along the perimeter of the mask in key areas where the mask would not normally mold to the user's facel, such as on the upper part of the mask along the nose and upper cheeks. The unfolded paper clip is approximately five inches long when unbent.

Rationale

The frame provides rigidity to the mask and increases the seal as it provides a tighter fit for the user. Since one of our main concerns included how well the mask would mold to the user's face, as that is directly related to the mask's sealing capabilities, we wanted to make it possible for users to adapt their mask's size to their own facial structure, customizing it in the process. The frame is our solution to that.

Next Steps

The following items are recommended for future development of the design.

Testing

User Testing. The design concept was reached through extensive user testing with mockups. These mockups were used to gather isight on which features to include in the final design. Upon completion of the final design concept, preliminary testing was done to ensure that the prototype met all of our requirements; however, further user testing is required in order to determine where the final design could be improved in future iterations. One example of how future user testing can be done is by creating several identical prototypes and enlisting the help of friends and family to test the prototypes in the field. In other words in order to test the real-world viability of the masks, our team would wear the mask prototype out in public and note areas where the mask performed well as well as areas where the mask could be improved.

Performance Testing. Extensive performance testing was done with the mockups that led to the creation of the final design concept; however, only preliminary performance testing was done on the prototype to show that it met our requirements. In the future development of the design concept, more performance testing would be needed to further improve the design in future iterations. In addition to gathering more data by conducting tests using our current testing methodology, new testing methodology could be created to further expose the strengths and limitations of the design concept.

Improvements to the Design

Mask Material*.* The mask material that was selected (pillowcase fabric) was chosen because it provided a good balance between breathability and effectiveness at filtering air particles. This material was sufficient for the first prototype;however, further research into household materials that can serve as the mask material should be done in order to further improve the design.

Wire Material. In the design concept, paper clips were used to provide the mask with the much needed rigidity and sealability it required. Paper clips were chosen because they can be easily found in most households and provide a good balance between moldability and strength. That being said, further research into wire materials should be conducted to ensure that our team is using the best option for providing the mask with rigidity and structure.

Cushion Material. Shoe insoles were selected as the material that would provide cushion between the paper clip and the user's face and also improve the seal of the mask. This material proved to be both easily accessible and effective at meeting our requirements. However, more research should be conducted into other household materials that can act as a cushioning barrier between the wire-structure and the user's face.

Conclusion

The prototype fulfills the requirements our team laid out in creating an effective mask that can be made without expertise and with common household materials. Some key elements of the design that were chosen to fulfill these requirements are:

- pillowcase fabric (120 thread ct.) capable of effectively filtering air particles while maintaining sufficient breathability
- elastic bands coupled with a pillowcase strap provides much needed comfort and adjustivility to the mask while also allowing for a tight seal
- paper clips serve to provide the mask with rigidity and moldability so that it seals to the face effectively
- shoe insole material provides a cushioning barrier between the solid paper clip and the user's face while also improving the masks's seal

Our users need a design that can be easily made with common household materials while maintaining competitive effectiveness with other alternatives. The design choices our team has made and the methods we've implemented in building the design are geared towards these users and they are sufficient in meeting the need of providing a good alternative to buying a mask.

Appendix A: Background Research

Top 20 Brainstorming Problems

Problems that are repeated the most:

Mask Issues

1. Hesitation in ability to reuse masks
    a. Existing solution: raise surrounding temperature of mask
    b. Limitation: requires intensive care and not being careful with the mask
    c. Potential solution: 3D printed sterilization cabinet (product exists for goggles, could implement for masks)
2. Mask shortage/availability at home
3. Mask fails to adequately have protection in nose area (can be seen when people breathe out quickly in cold temperatures and fog up glasses, demonstrating air can enter and escape through that area)
4. People are selling fake masks.

Essential items and care

5. Safe access to groceries/medicine
6. Touching face too often
7. Lack of personal interaction with others, physical/emotional isolation
    a. Existing solution: Zoom, calling, texting
8. Lack of exercise by those in quarantine/staying in place
    a. Solution: YouTube videos, apps
    b. Limitation: none
9. How to sanitize groceries

Social/economic issues

10. Remote learning is a roadblock to many students
11. Workers laid off or minimized wages indefinitely
12. Stigmatization and discrimination toward Asian population

Coronavirus Information

13. There is a lack of verification for a lot of products / apps that aim to solve COVID-19 related problems
14. There has been a general bottleneck in supply chains for COVID-19 related products and essential products in general

15. Media misinformation
16. How to know if people have had it/who is immune
17. Lack of testing kits to identify asymptomatic carriers or people with coronavirus

Patient/healthcare problems

18. Complications resulting from post-release from ICU: patients often possess respiratory issues, tissue scarring, etc.
19. People who work at hospitals have to return to their families not knowing if they've been infected or not
20. Grocery workers, postal workers, other essential workers working without protection

Decision Matrix

Topic	Impact			Feasability			Interest	
Subtopic	**Number**	**Who**	**Effectiveness**	**Design**	**Testing**	**Pricing**	**Personal Interest**	
Description	How many people will this impact?	Who is going to use the product? Are they healthcare workers, other essential workers, etc	Does the product have a significant impact on stopping the spread of the disease?	How hard is it going to be to make this product / method?	How are we going to prove that the device works? How do we do user / performance testing?	How much is it going to cost to make / manufacture the product or method?	How do we feel about this problem in general? Is it interesting? Is it going to be fun to see where we go with it, or is it just going to be a huge challenge?	
Problem								
Hesitation to reuse masks	**Number**	**Who**	**Effectiveness**	**Design**	**Testing**	**Pricing**	**Personal Interest**	**Total**
Sophie	3	1	2	2	2	2	2	14
Kelvin	3	2	2	2	2	2	2	15
Derex								0
Ross	3	1	2	3	3	3	2	17
								11.5
Mask and Respirator shortage/availability	**Number**	**Who**	**Effectiveness**	**Design**	**Testing**	**Pricing**	**Personal Interest**	**Total**
Sophie	3	3	2	2	2	2	2	16
Kelvin	3	3	2	2	2	2	2	16
Derex								0
Ross	3	3	3	1	1	2	3	16
								12
How to sanitize groceries	**Number**	**Who**	**Effectiveness**	**Design**	**Testing**	**Pricing**	**Personal Interest**	**Total**
Sophie	3	2	1	2	2	2	3	15
Kelvin	3	1	1	2	3	1	1	12
Derex								0
Ross	3	1	1	3	3	3	1	15
								10.5
Essential workers working without protection	**Number**	**Who**	**Effectiveness**	**Design**	**Testing**	**Pricing**	**Personal Interest**	**Total**
Sophie	3	2	2	3	1	2	3	16
Kelvin	3	2	2	2	1	2	2	14
Derex								0
Ross	2	2	2	2	1	2	1	12

Appendix B: Project Definition

Mission Statement: To develop a mask prototype that can be made at home for users who wish to protect themselves and others when going out in public spaces.

Project Deliverables:

- Final report (distributed online)
- Presentation and poster during a virtual interview
- Sketches and/or Drawings of a Prototype
- A Physical Prototype

Constraints:

- All deliverables due June 18, 2020
- Must be built at a minimal cost
- Must be build with materials that can be found at home
- Must be able to be build with minimal tool use
- Must not require specialized skills or expertise in building. I.e. no sewing, etc.

Users / Stakeholders:

People Living in the U.S.

User(s) Profile:

People who are practicing social distancing but wish to infrequently go out in public to meet their essential needs.

User Scenario:

Ross, a 19 year old college student living at home with his parents is tasked with getting groceries for the next two weeks and decides he needs to go to the supermarket. He is practicing social distancing in order to lessen the spread of coronavirus and alleviate the strain on the public health system, so he has not left the house for weeks. Knowing the characteristics of COVID-19, Ross realizes that if he goes to the supermarket he could end up unknowingly exposing dozens of people to COVID-19 if he is asymptomatic and has the virus.

Because of this, he responsibly wants to wear a mask in order to lessen the chance that he will give someone the coronavirus, however he does not have access to a mask because there are none available. So in order to do his social duty, Ross does some research online about how he can create a mask at home. To his dismay, however, Ross finds that despite the multitude of videos and articles detailing how to create a mask from home, including instructions provided by the CDC, there are no masks that have been quantitatively proven to be as effective as the ones you used to be able to buy from the store.

Realizing his conundrum, Ross decides that he simply cannot allow himself to go out in public without knowing for sure that the mask he can make will protect others from himself. “But how will my family eat!”, Ross thinks to himself. Wallowing in despair, Ross comes to the conclusion that nothing can be done and that his family will just have to order from Uber Eats™ until COVID-19 is eradicated.

With a look of defeat on his face Ross informs his mom of his conclusion. Ross’s mom, however, having done more research, says to her son, “You silly teenager! Have you not read the article published by DTC Section 8 Team 3 about how to make a scientifically proven working mask?” Ross is taken aback. “No,” he says with a look of excitement on his face, “I’ll look at that now!”

Ross runs to his computer, frantically searching for the article his mom mentioned until he finally finds what he had been looking for all this time: *How to Make an Effective Mask at Home*, by DTC Section 8 Team 3. “Wow!” Ross exclaims, “These guys have covered everything!” Leaping from his desk chair In a frenzy, Ross scours the house for all of the necessary materials and finds them in no time. Unwavering in his quest to make a mask, he lays his spoils on the kitchen table, grabs a pair of scissors and a pencil, and gets to work. In the blink of an eye his mask if finished. Beaming at his achievement, he lifts the mask up like that scene from the Lion King and proclaims, “I can finally go to the grocery store! And it’s all thanks to DTC Section 8 Team 3.”

Needs Identification, Metrics, and Specifications:

Category	**Needs**	**Metrics**
Weight	Light enough to easily lift and move	2.3 g
Implementability	Low cost	Amount in dollars
	Accessible materials	Availability in homes
Effectiveness	Block airborne particles	Passes the flame test, water test, and smoke test
Comfort	Comfortable to wear for long periods of time	Skin irritation marks

Rationale

- Weight: The prototype should be portable so that it can be used throughout travel. If it is too heavy, it may not be supported by the contact points / bands.
- Implementability: Our prototype should be easily replicated throughout other households. To do this, we aim to devise a product that is low cost, in terms of the cost of materials, as well as accessible, meaning that they should be materials in stock at home or at stores.
- Effectiveness: This is one of the primary targets of the mask: it must be effective in preventing the spread or contraction of the virus. It should be comparable to a surgical mask.
- Comfort: The mask should be comfortable to wear so that people feel encouraged to use it.

Needs Identification, Metrics, and Specifications

- Must be more effective than comparable alternatives
- Must be more effective than comparable alternatives

Appendix C: Mockup Overviews

We developed multiple mockups in our design process. These include the Coffee Filter Mask, the Sock Mask, the Sleeve Mask, the Sponge Mask, and the Adjusted T-Shirt Mask.

Coffee Filter Mask

Design Concept

The Coffee Filter Mask combines multiple layers of material to filter air and water particles more effectively than a DIY t-shirt mask. The design is intended to bridge the gap between the effectiveness of a t-shirt mask and a high-functioning respirator.

Rationale

Masks made from t-shirts can be deceptively ineffective since cotton, the fabric that most tshirts are made from, is a relatively porous material. Adding a more impermeable coffee filter increases the chance of preventing the wearer from spreading anything through their breath. The Coffee Filter mask is made from materials commonly found at home and is intended to be easily made by anyone with the instructions to do so. The mask should be almost as easy to make as a t-shirt mask to increase the likelihood of its everyday use. It is meant for personal use by anyone that doesn't have access to a respirator but would like more protection than a t-shirt or bandana.

Questions the mockup aims to address

<u>Construction</u>

1. Is the mask easy to make at home?
2. Will the coffee filter be sewn in? Glued? Held in place by rubber bands?
3. In the absence of a coffee filter, can tissue paper be used as a filtering layer?
4. Would the mask benefit from a rigid frame in addition to filtering layers?
5. Can the mask be reused? If not, what materials need to be replaced after each use?

<u>Tight Seal</u>

6. Is one coffee filter sufficient for air filtration? Will two filters inhibit breathability?
7. How much air escapes from the edges of this mask?
8. How many points of contact does this mask have compared to a t-shirt mask?

<u>Comfort and Breathability</u>

9. Is a headband more comfortable than typical around-the-ear straps (as on a surgical mask)? Does it stay on as well?

10. Is this mask comfortable? Does it create marks on the skin after an hour or more of use?
11. Does this mask feel breathable and for how long?

Visual Depiction

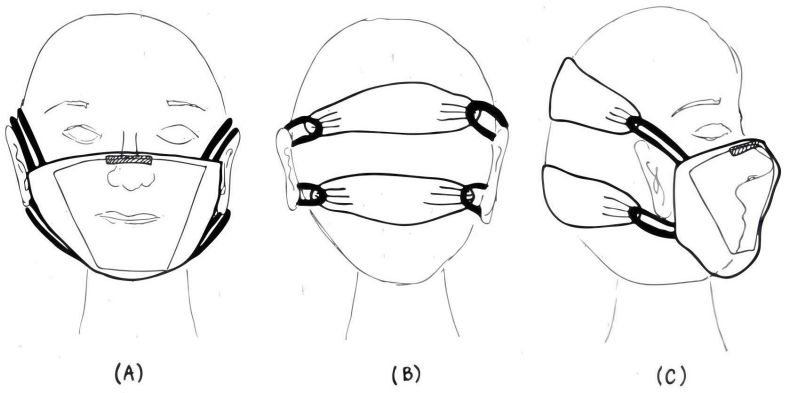


FIGURE 1. *Illustration of how the Coffee Filter Mask is to be worn*. The mask is drawn transparently to show its proportional relationships to facial features. (A) Front view. The coffee filter and fabric layers cover the nose and mouth. (B) Back view. Two strips of cotton fabric hold the mask in place and are attached to the mask by elastic bands. (C) Profile view. The small metal strip presses down over the shape of the nose. The mask covers below the chin.

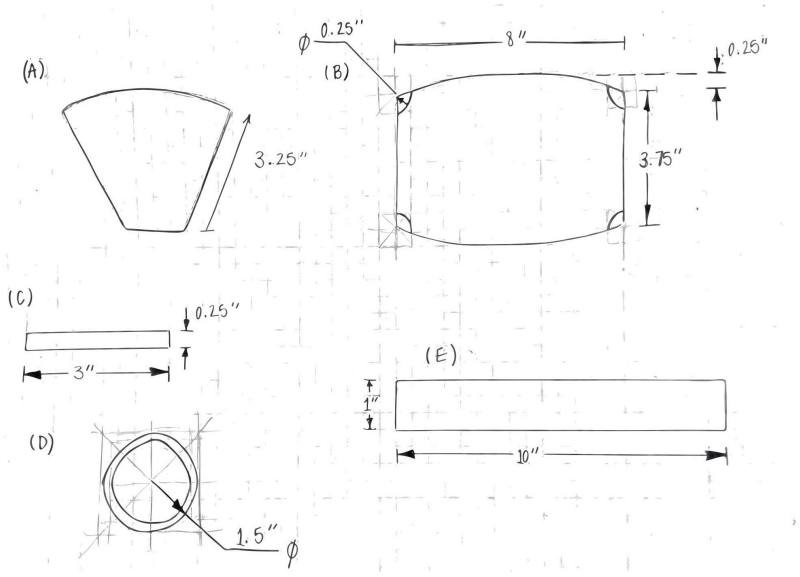


FIGURE 2. *Sketch of the pieces of the Coffee Filter Mask*. (A) Coffee filter. (B) Mask body fabric with radial seams for elastic to be threaded. (C) Malleable metal strip. (D) Elastic bands (quantity 2). (E) Cotton fabric bands (quantity 2).

FIGURE 3. *The Coffee Filter Mask mockup.* Two layers of tissue paper are stitched to a cotton body and straps are attached by hair ties.

FIGURE 4. *Profile view of mask being worn.* Two hair ties attach the body of the mask to the head straps.

Description

The Coffee Filter mask is made from layering a folded coffee filter and larger, thick piece of fabric. The mask will be worn such that the coffee filter touches the user's skin and the cotton fabric faces outward. These two pieces may be sewn, taped, or glued together as long as the coffee filter is secured to be covering the nose and mouth. If the mask feels breathable, a second coffee filter layer may be added to lessen the likelihood of particles passing through the mask. Each of the four corners will be folded over an elastic band and stitched in place. Each pair of elastic bands attaches a strip of cotton fabric (as cut from a t-shirt) to the mask. Two cotton pieces worn like a headband limit the discomfort caused by a surgical mask that loops around and pulls on the ears. Rubber bands or hair ties may be used for the elastic bands: whichever the user deems most comfortable. A thin metal strip is positioned at the top center of the mask body fabric. A short piece of wire or a strong twist tie can be substituted for a piece of malleable metal. Pressing the metal down around the form of the user's nose will limit the flow of air and water particles out of the top edge of the mask. The metal strip insert will close the gaps formed between the user's cheeks and the mask when the fabric is laid over the peak of

the nose. While this seal does not protect against 100% of air and water particles, it minimizes entry points without compromising breathability.

The most pressing questions from the above list that cannot be answered through research are those regarding reuse (5), tightness (7), and breathability (11). We will be able to address questions 5 and 11 by wearing the mockup for up to an hour and evaluating how breathable it feels and checking if it gets too damaged for reuse. The mockup will address question 7 through performance testing, specifically through the candle and smoke tests.

Sock Mask and Sleeve Mask

Although masks currently exist in the market, they may not be effective; even worse, they may be expensive, have loose seals, or are generally uncomfortable to wear. We identified this gap in the market as our White Space Problem. We hope to build, design, and implement a mask that meets all of our design criteria:

- Comfort
- Breathability
- Effectiveness / Tightness of seal
- Implementability At Home

I created two distinct mockups to further our research.

THE SOCK MASK

Design Concept

Overview

The Sock Mask is a mask cut out from half of a sock with two cuts at the ends. These cuts offer loops for the mask, so that a user can wear it without needing any knowledge of sewing. It is altogether one piece; thus, it is convenient and not susceptible to failure due to different parts. Below are two pictures for reference:

Figure 1: Original sock with cut portions

Figure 2: Sock Mask unfolded

Rationale

We chose to develop the Sock Mask because we believed it met all our criteria of comfort, breathability, tight sealing, and ease of implementation. Since the material is comfortable for the feet, we thought it would be comfortable for the face as well. The Sock Mask provides a soft, cushion material that seems to be both comfortable and breathable, and thus not irritate the skin or leave any marks. Additionally, some socks have unique capabilities, such as moisture-wicking abilities. Such properties could be useful in our research of developing a mask with tight and effective sealing. Furthermore, its material stems from socks, a common household good, which tend to be low-cost, high bulk items -- allowing it the additional benefit of being highly reproducible. If users preferred, they could create multiple masks with little cost.

Questions We Seek to Answer

Through this mockup, we hoped to answer the following questions, organized into high and medium priority questions. High priority questions were the most important ones vital to the design and were answered through the mockup, while the medium priority ones were more exploratory and can be found through further testing.

High Priorities

- Is the Sock Mask a new idea? If so, what are its faults? Its strengths?
- Will the Sock Mask pass the flame test?
- Will the Sock Mask pass the water test?
- How does the Sock Mask compare to a surgical mask?
- Is the Sock Mask comfortable? How long can it be worn comfortably?
- Will the Sock Mask restrict air flow *too much*, to the degree that it makes it uncomfortable to breathe?
- How difficult is it to create? How difficult would it be for a user to develop and implement one at home with their current supplies?
- Does the Sock Mask have any unique strengths? Weaknesses? How should we move forward with these weaknesses in mind?

Medium Priorities

- Will the Sock Mask require multiple layers for more protection?
- If multiple layers are used, how do we ensure that it is one cohesive product? Is there a way to stitch together the two fabrics?
- If multiple layers are used, what fabric belongs on the outside? On the inside?
- What other fabric can be used as substitutes?
- Should there be an inner layer between the mask and the face?
- How many contact points should there be?
- Should the mask attach behind the ears? Or behind the head? Which way would be more secure? Which way would be more easy to create?
- Is there a specific sock that works better than others (ex: dress socks vs athletic socks)?
- Can the Sock Mask prevent fogginess that often comes with breathing out of masks?

Mockup of Design

Visual Depictions of Mockup

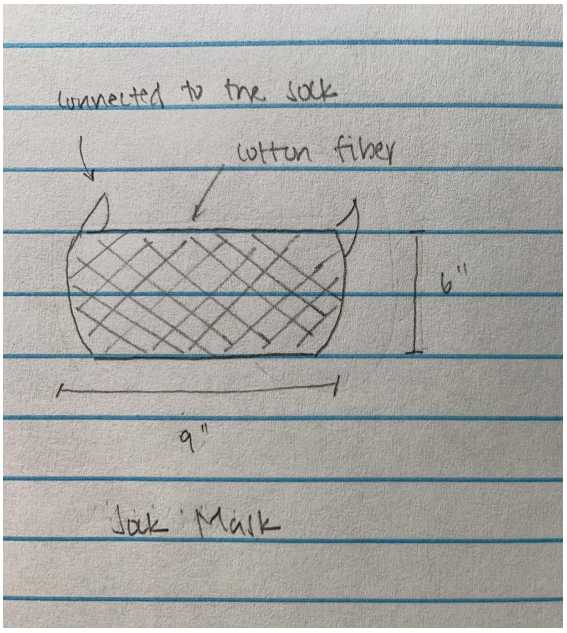


Figure 3: Graphics sketch of mask

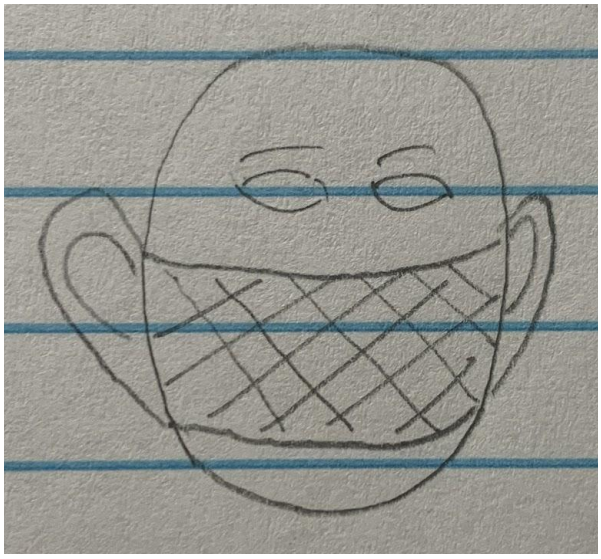


Figure 4: Sketch of user wearing mask

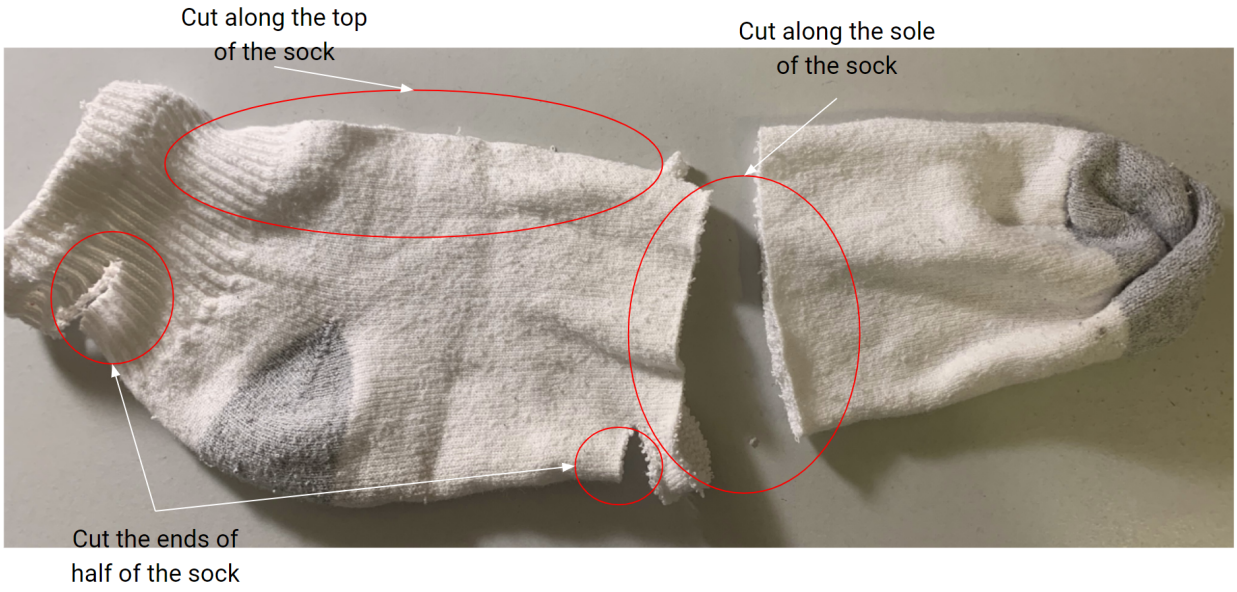


Figure 5: Annotated photo of the cuts along the sock

Figure 6: Sock Mask unfolded

Description of Mockup

The Sock Mask was created by cutting portions out from a sock. The left and right cuts along the left half of the sock (shown in Figure 5) lead to the two holes in the mockup, holes that allow for easy attachment to the ears. The main fabric in the front captures and guards against particles. This style felt better than others because it was composed of one component, leading to a tighter and more effective seal. Additionally, we thought the two points of contact behind each ear would offer more stability and security, compared to a strap behind the head.

In building the mockup, we sought to assess the Sock Mask based on our four design criteria: comfort, breathability, tight sealing, and implementability at home. The tightness of sealing would be assessed through tests such as the flame test -- composed of attempting to blow out a flame while wearing the mask at different distances, shedding light on its effectiveness in preventing the flow of particles -- while the breathability, comfort, and implementability would be assessed on a scale, 1-10. Furthermore, I aimed to answer the high priority questions, including how the Sock Mask compared to a surgical mask and its strengths and weaknesses.

I outlined those strengths and weaknesses below. In creating the Sock Mask, I created two different iterations of it. First, I created the Sock Mask out of a cotton ankle sock, as depicted in Figure 6. Next, I created the mask out of a polyester dress sock. Both had the same advantages

-- mainly, ease of implementation -- and disadvantages -- including lack of comfort and breathability.

Advantages

This mask was easy to build and implement, making it ideal to be constructed in other homes as well as it does not require any knowledge of sewing. Additionally, the design includes straps around the ears, mde from the main fabric, because that way, it is built in one solid piece, without requiring any additional material and thus having a tight seal. Thus, it passed one of our design criteria: ease of implementability at home.

Disadvantages

As I tested the Sock Mask, I realized it possessed many disadvantages. It namely failed to meet two of our design criteria: comfort and breathability. The other design criteria, tight sealing or effectiveness, was unclear.

Although I thought the mask would be breathable, the fabric made it difficult to breathe. When I wore the Sock Mask, I realized that the face protection felt small and tight. Furthermore, the straps provided immense pressure on my ears, preventing me from wearing it for more than five minutes. It felt difficult to breathe as well. I then created the Sock Mask from a large polyester dress sock. Despite the difference in size, the Sock Mask still did not adequately fit my face. I found that it posed the same problems as the cotton Sock Mask: it felt uncomfortable and unbreathable. On a scale from 1 to 10, I felt that the cotton mask was slightly more comfortable (4), compared to the polyester (3). In terms of breathability, neither felt breathable: 2 out of 10 for both.

Future Implications

After testing with two different materials and two different socks of different sizes, the Sock Mask felt uncomfortable and unbreathable, preventing me from wearing it for longer than five minutes. For people with smaller faces, it could potentially be an option. However, because the Sock Mask cannot be adapted to different facial sizes, and failed to meet two of our four criteria, we felt that it was not a viable direction for our project. After reviewing these results, I created a second mockup, the Sleeve Mask.

THE SLEEVE MASK

Design Concept

Overview

The Sleeve Mask is a mask made out of two different materials: a long, thin cotton strap and a thicker cotton face covering. With two different components, the user has more flexibility to exchange materials and strengthen different aspects of the mask. Our design criteria remained constant:

- Comfort
- Breathability
- Tightness of Seal
- Implementability At Home

Figure 7: Sleeve Mask on a user

Rationale

We chose to develop the Sleeve Mask because I found the previous Sock Mask to be uncomfortable and wanted to continue testing different designs. Additionally, we believed that this mask would be better suited in meeting our criteria. Since cotton t-shirts tend to be breathable, we thought that the Sleeve Mask would be as well. Additionally, with its strap behind the head, we thought that it would be more comfortable compared to the Sock Mask, which placed pressure behind the ears. Additionally, the Sleeve Mask came from two low-cost, common household goods, such as pillow covers and sleeves of t-shirts, allowing it to be highly reproducible and cost-effective.

Questions We Seek to Answer

Through this mockup, we hope to answer the following questions, organized into high and medium priority questions. High priority questions were the most important ones vital to the design and were answered through the mockup, while the medium priority ones were more exploratory and can be found through further testing. These questions have been slightly adapted from the previous mockup's questions after analyzing the results of the Sock Mask.

High Priorities

- Will the Sleeve Mask pass the flame test?
- How does the Sock Mask compare to a surgical mask?
- Is the Sleeve Mask comfortable? How long can it be worn comfortably?
- Does the Sleeve Mask restrict air flow *too much*, to the degree that it makes it uncomfortable to breathe?
- How does the Sleeve Mask compare to a surgical mask?
- How difficult is it to create? How difficult would it be for a user to develop and implement one at home with their current supplies?
- Is having a strap behind the head more comfortable than having ear loops?
- What are its unique strengths? Weaknesses? How can we leverage these strengths in future mockups and our prototype?

Medium Priorities

- Will the Sleeve Mask require multiple layers for more protection?
- If multiple layers are used, how do we ensure that it is one cohesive product? Is there a way to stitch together the two fabrics?
- If multiple layers are used, what fabric belongs on the outside? On the inside?
- What other fabric can be used as substitutes?
- Should there be additional layers between the mask and the face?
- How large should the t-shirt be?
- Can the Sleeve Mask prevent fogginess that often comes with breathing out of masks?

Mockup of Design

Visual Depictions of Mockup

Figure 8: Strip of pillow case (approximately 2 by 26 inches)

Figure 9: Sleeve cutout (approximately 5 by 7 inches)

Description of Mockup

The Sleeve Mask is a mask with two components: a long strip and a face covering. In creating the Sleeve Mask, I cut out a portion of a pillow case along the long end. A standard pillow case is 20 by 26 inches; hence, it had about 2 inches in width and 26 inches in length. The sleeve cutout in my case is approximately 5 by 7 inches. The Sleeve Mask is tied by the user every time they wear it by placing the strip of cotton around their neck, placing it through the ends of the sleeve cutout, and tying a knot behind the head to create a tight and effective mask. The sleeve fabric insulates the openings on the face while the straps provide an adjustable sizing and allows for extremely tight to moderately tight sealing, attaching behind the head.

In building the Sleeve Mask, we applied the results from the Sock Mask. We built this one with straps that attach behind the head, so that there is no pressure placed on the fragile ear tissue. Additionally, because there are two components, this style offers distinct advantages: users can place material between the outside covering to provide an interior covering or add additional comfort, and users can swap out the two pieces at any time. If the straps are not elastic enough, or do not provide enough of a seal, they can be easily replaced. If the covering is not large enough or comfortable, it can be swapped out for a different fabric of a different size.

By building the mockup, I sought to assess the Sleeve Mask on the basis of comfort, breathability, effectiveness of sealing, and implementability at home. Comfort, breathability, and

implementability at home can be measured through building and feeling the mask on a scale from 1 to 10. Its effectiveness can be assessed through the flame test, allowing me to identify the particle flow in and out of the mask. Additionally, I hoped to answer the high priority questions and identify the Sleeve Mask's strengths and weaknesses. They are outlined below.

Advantages

The Sleeve Mask was easy to build and implement, required few materials, and felt comfortable. Like the Sock Mask, it required no stitching or sewing, only scissors and cloth. Since it requires only a pillow case and a t-shirt, we felt that it could be affordable and widely implementable for the general public. Furthermore, it can be adjusted in terms of the size of the covering and the strap pressure.

Regarding comfort, the cotton from a t-shirt felt more comfortable and breathable than the cotton from a sock. Whereas the Sock Mask felt like it was heavily inhibiting my breathing, the Sleeve Mask felt much more breathable. For both comfort and breathability, I would rate it 8 out of 10.

When I performed the flame test to measure its effectiveness in blocking airflow, the flame wavered slightly rather than going out, meaning that the Sleeve Mask effectively restricted the particles from entering and leaving. Had the flame gone out, the Sleeve Mask would have been marked as ineffective and failing to meet one of our main design criteria.

Ultimately, it passed our four criteria: comfort, breathable, effective, and widely implementable. While adjustability was not a criteria, it provided a hidden advantage, in that it can be adapted for different sizes by creating it of different materials. The Sock Mask, on the other hand, had only the base size, which did not fit, even after I tried different socks of different fabrics and sizes.

Disadvantages

Although the Sleeve Mask passed the flame test, I felt that the material was *too* thin. More material could be used to prevent airflow and provide more protection. Additionally, the straps were not always securely tied together. At times, I had to retie the knot behind my head to readjust the mask -- and when I did so, the mask would loosen too much, and I would have to reassemble the mask.

Additionally, when untying the mask and rewearing the mask, it could be difficult to identify which side of the sleeve faced the front. In future iterations, it would be better to mark the outside covering with distinct coloring; that way, the user does not accidentally wear the mask inside out, with the outside covering that had been exposed to airborne particles facing their mouth.

Future Implications

The Sleeve Mask felt much more viable compared to the Sock Mask. It posed many advantages, which we hope to leverage in future designs and our prototype. Specifically, we hope to implement the strap behind the head rather than the ears to ensure users' comfort.

Additionally, we hope to have thicker layers to offer more protection and potentially an outside protective layer as well as an inner layer that provides the user with more comfort.

Sponge Mask

Design Concept

Overview
The Sponge Mask Seeks to improve user comfort when using a mask. One of the reasons people find masks uncomfortable is because it is hard to breath while using a mask due to the lack of airflow. Our design is meant to meet the multiple criteria developed for assessment as well as their tests, ideally the final product will fit all of these criteria. These criteria are: safe/air tight, comfortable, breathable, implementable at home with available materials, and easily accessible in terms of ease of instructions and costs. The Sponge Mask specifically chooses to focus on the breathability part of this problem.

The Sponge Mask closely resembles other types of face masks made at home such as t-shirt masks, sock masks, or coffee filter masks. The materials used to make the Sponge Mask should be low cost, easily accessible, and bountiful. The distinguishing factor of the Sponge Mask is the extra small layer that will be sewn onto the mask that will be able to hold a cold sponge which will hydrate the inside of the mask making it more comfortable and breathable.

Rationale
Unlike other masks, the Sponge Mask is able to cool down the inside of the mask through the use of a damp sponge, which makes it easier to breathe while wearing it. This feature would incentivize people to wear the mask more often which would reduce both the chance of the user spreading the virus or coming into contact with the virus.

Questions We Seek to Answer

Comfort

- How comfortable is it to wear the mask?
- How much harder is it to breathe with the mask on compared to breathing regularly?
- How does the Sponge Mask's breathability compare to masks currently on the market right now?
- Will it be comfortable to have a sponge touch the user's face?

Design Questions

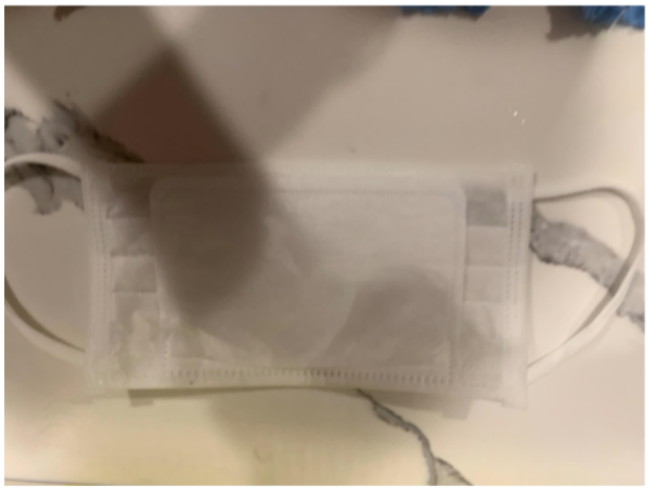
- How hard is soaking the sponge and reinserting it back into the mask?
- How damp should the sponge be?
- How long does the sponge stay damp?
- How difficult is the mask to create?
- How accessible are the materials for the mask?
- How long does it take for the user to create the mask?
- Where on the user's head can the Sponge Mask be attached?

Safety

- Will the Sponge Mask pass the flame test?
- Will the Sponge Mask pass the water test?

- Will the Sponge Mask prevent respiratory droplets from easily passing through the mask?

Visual Depiction of Sponge Mask Mockup



Base Mask Used

Two different sizes for sponges that could be used

(Left: single long sponge, Right: four square sponges)

Four sponges in mask

Long sponge in mask

Description Of Sponge Mask Mockup

The Sponge Mask is made using a premade mask at it's base. This mask is a typical surgical mask with the addition of a layer of fabric that lets it hold something. In this mockup, this layer will hold the sponges. There were ultimately two sponge shapes that I decided on, one long 6 inch by 2 inch sponge or four small 2 inch by 2 inch sponge squares. The idea behind the four small squares was to leave a gap in between for the nose so the fabric of the mask would be the material touching the nose instead of the sponge. The long sponge was intended to maximize sponge area in order to help keep the inside of the mask cool for an extended amount of time.

Since the purpose of this mockup is to determine the feasibility of sponges in the mask, the testing will involve wearing the mask and seeing if the sponge does actually help cool down and hydrate the inside of the mask. The testing should answer the questions listed above with the questions involving the use of the sponge being the most important for this mockup.

Adjusted T-Shirt Mask

Design Concept

The design concept for this mockup explores both the T-Shirt mask outlined by the CDC and a modified version of the T-Shirt design.

Rationale

T-Shirt masks in general are intended to be quick and easy solutions to not having a mask readily available. They source common household materials, require only a few tools to make, and do not require any expertise to make. The rationale behind this is that if the concept is easily accessible, then more users will be able to utilize and benefit from the concept. This meets the design requirement of helping as many people as possible. In addition to accessibility of materials and building, the mask also must be comfortable for the user. If the user experiences discomfort then they are less likely to wear the mask and thus will not be protected. This is why the adjusted design utilized a curved shape and flexible dimensions in order to fit the user as best as possible. Finally, the mask must also be effective at trapping particles from sneezes and coughs, and it must allow for good airflow for the user. The adjusted design also accounts for these two problems because a well-fitting mask is more likely to seal with the user's face and thus prevent the spread of harmful particles.

Key Questions

Comfort

- How easy is it to put on / secure the mask?'
- How comfortable is the mask?
    - Does the mask leave marks on your face?
    - Is the mask irritating after prolonged use?
- How easy is it to take off the mask?

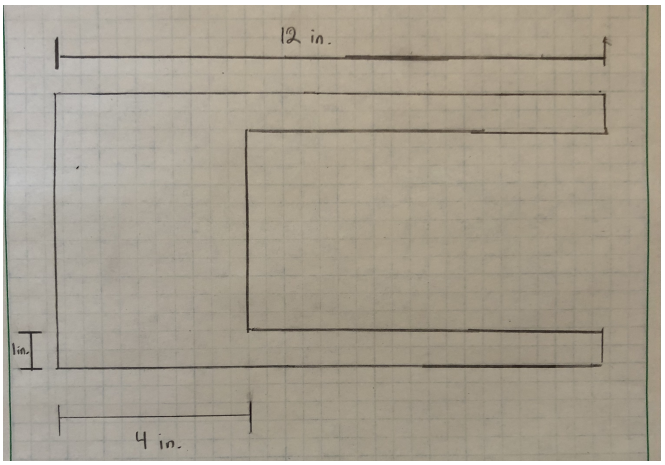
Creating the Mask

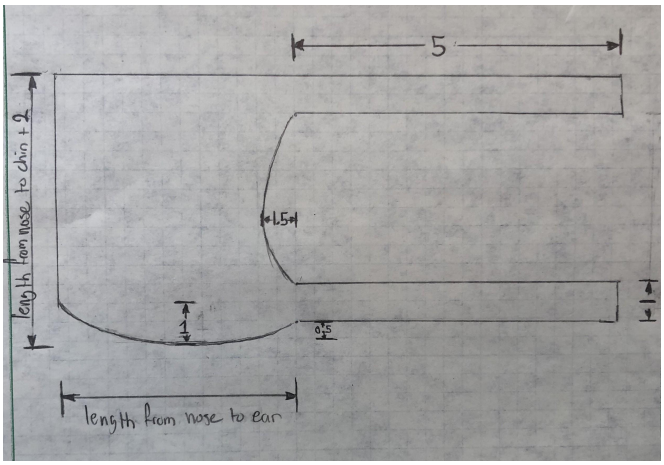
- Are the materials required easily available?
    - How long did you spend searching for / obtaining the materials?
- Are the building instructions clear and easy to follow?
- How long did it take you to make the mask?

Effectiveness

- Perform the candle test
    - At which point did the mask fail the test if at all?
    - Was the test a good representation of how you would normally use the mask?
- Perform the Water Test
    - At which point did the mask fail the test if at all?
    - Are you confident that the mask would prevent you from spreading droplets from coughs and sneezes?

Sketches





CDC T-Shirt Concept **Adjusted T-Shirt Concept**

Pictures

CDC T-Shirt Concept **Adjusted T-Shirt Concept**

Description

The CDC T-Shirt concept copies exactly the procedure found on the CDC's website regarding creating a T-Shirt mask. As seen in the pictures, the CDC mask does not fit well to the user's face due to the fact that the dimensions are inflexible, and the shape of the mask is inadequate. The Adjusted T-Shirt Concept takes the CDC's guidelines and modifies them to both make the

mask more comfortable and more effective. As seen in the picture, the adjusted mask fits the user much better than the CDC designed mask, allowing for better protection and comfort.

Appendix D: User Profiles

Derex's User Profile: Doctor's Visit

Sylvie is a 39 year old woman living in the suburbs. It's time for her annual checkup, and she has a few questions for her doctor: a few aches here and there, a red spot that *just won't go away*. And did they have any advice to help her with her worsening insomnia? All questions and concerns she was hoping her physician could answer.

But in this pandemic, it was becoming more and more dangerous to venture out. She had delayed her visit for months now: in February and March, she had dozens of deadlines for work; in April, she was running errands for her family.

May arrived. The world slowed down, as did her work. Her company told her to work from home, but does anyone *really* work from home? She had put off her checkup long enough.

She knew that her visit would be risky. A physician's office, with plenty of people idling in the waiting rooms, would be filled with dangers. Yes, she knew that she'd have to observe social distancing, shying away with anyone that looked remotely sick, and generally avoid people. She does the same in her routine visits to the grocery store, but the risk seemed infinitely greater visiting an office where asymptomatic people could be checking in, or worse, sick people confirming their status. She couldn't bear the thought of coming back from the visit, carrying around COVID-19 unknowingly and infecting her family members.

Sylvie needed a mask, a secure and safe mask that would protect her. She searched online for N95 masks, but by the time the coronavirus started making waves in the US, it was too late--the N95's were all sold out, and the few remaining went to healthcare facilities. Surgical masks, too, were getting more and more scarce.

Fortunately, Sylvie found the mask designed by our DTC team, the CATWOT (the Comfy Alternative to What's out There). She wanted to know that her mask would be effective in blocking out air particles--and we were able to assure her that our mask does just that, since it passed both the flame test and the water test. Because our mask is also a DIY design, Sylvie was able to build multiple masks within hours.

With this mask, she felt safer, knowing that she had thoroughly validated it herself. With less apprehension, she paid a visit to the physician, avoiding people all the way. In the situations where that wasn't possible, she felt better, knowing that her mask effectively blocked out the water droplets capable of spreading the coronavirus.

Ross's User Profile: Supermarket Trip

Rosa is a thirty-five year-old single mother living at home with her two children. Due to the pandemic, she is working from home and is also taking care of her children because they can

no longer go to school. Rosa knows that she needs to go out to buy groceries at some point since her family is running low on food, but she is worried about potentially exposing her family to the virus if someone at the store is sick. So, she decides that in order to keep her and her family safe she must wear some protective equipment, namely, a face mask. However, Rosa cannot afford to buy a fancy mask and she doesn't have the time or equipment necessary to make a home-sewn mask herself. Rosa mulls over her options online but is becoming increasingly worried that there isn't anything out there she can make that will keep her and her family safe.

Kelvin's User Profile: Grocery Worker

Bob is 22 and recently got a job as a cashier at the Trader Joes a couple of blocks away from his home in downtown Chicago. He wakes up at 8am on weekdays to prepare for the day shift at work, which runs from 9 to 5. After work, he goes back home to relax by pulling up a Netflix show or playing *Call of Duty: Warzone* with his buddies. He goes to sleep around 2am on weekdays so he can get enough sleep for the next day. On weekends he gets to wake up late and just play *Warzone* with his squad all day until 5 in the morning.

In February when Bob heard about the spread of COVID-19, he wasn't really worried because he thought it wouldn't affect him in the slightest. He thought that he would just continue to stay at home and game with the boys so he wouldn't be at much risk. However, he has grown increasingly worried over the past few months after realizing how many people he comes into contact with as an essential worker at Trader Joes.

When receiving money from the customers for their purchases, their hands sometimes touch which may pass the virus over to him, so he has started to bring gloves to work because he has already used up all the gloves his workplace provided. His workplace also provided a few masks, but they are flimsy and don't look reliable. He knows that he has to wear a mask because there is a risk of coming into contact with COVID-19 even when a customer says a simple "Thank you".

Bob decides to look into masks online and is unable to find any vendors selling masks at a reasonable price. As a result he looks into DIY masks instead--he finds a lot of videos talking about T-shirt masks, or Coffee filter masks, but he isn't too sure about their capabilities. Then he stumbles upon the design made by The Corona Destroyers which is a DIY mask made from easily accessible material that he can find at home and is safer than a surgical mask. He decides to build one for himself and walks into work the next day feeling a lot safer.

Sophie's User Profile: Mail Carrier

Tom is 32 and works as a mail carrier for the U.S. Postal Service. He lives in Chicago, and his typical work day lasts from 9am to 5pm. He drives a USPS truck and delivers mail and packages Monday through Saturday.

When the COVID-19 pandemic started making headlines in late February and the possibility of a Chicago lockdown loomed, Tom wondered what might happen to his job at the Postal Service. He is an essential worker and continues to work as usual. Tom hasn't taken any time off recently but fears losing his job if he feels sick and stays home. He is particularly afraid of an unofficial policy[1] that if an employee takes more than a few days off work, their positions may not be waiting for them.

Tom knows he is at high risk for contracting the virus since he doesn't have the proper protective equipment to be working every day. He has run out of the small supply of surgical masks provided to him by his employer and has to use winter gloves he's brought from home to handle the packages and mail touched by dozens of other people. Tom also worries that there is no place for him to wash his hands regularly on his postal route as the CDC recommends.

When he runs out of surgical masks, Tom decides to research masks that he can make on his own. He starts by chopping up an old t-shirt, but he can tell when his glasses fog up that the mask isn't neatly sealed and is barely having an effect. He digs deeper into other solutions he can build from home--he doesn't want someone like him to have to deliver supplies for his mask. Tom knows he won't be able to achieve an N95 level seal that he's seen on healthcare workers, but he wants a mask that will protect him more than an old t-shirt.

[1] A USPS employee reports receiving warnings after three missed days of work.
Source: Herships, Sally. "Postal Workers Say They Lack Supplies, Training To Protect Themselves From Virus." *NPR*. NPR, 24 Mar. 2020. Web. 14 Apr. 2020.

Appendix E: Bill of Materials

Item	Description	Vendor	Unit Cost	Total Cost	Alternate Vendor	Unit Cost	Total Cost
Pillow Case	Twin size	Home	$0.00	$0.00	Amazon	$3.995	$7.99
Paper Clip	Standard size	Home	$0.00	$0.00	Amazon	$0.0466	$2.33
Shoe Insole	Women's size 4.5-9.5	Home	$0.00	$0.00	Amazon	$3.33	$9.99
Hair Ties	4mm hair ties	Home	$0.00	$0.00	Amazon	$0.15	$4.11
			Total: $0.00				**Total: $24.42**

Appendix F: Instructions for Construction

VIdeo Plan and Script

First, gather your materials. You will need a pillowcase, some medium-size paper clips, an old tennis-shoe from which you will take the insole, some hair ties, and some tape (electrical is best, but regular tape works too). You will also need some tools. Grab a pair of scissors, a pencil, ruler, and a stapler.

With that done, you will need to either print out the template and trace it on the pillowcase, or you can also just sketch the cutout onto the pillowcase according to the specifications with a pencil and ruler. In order to obtain the best fit for the mask you should take some measurements of your face before you cut out the template, but you can also just use the measurements given. Make sure that the long left edge of the mask template is on an edge of the pillowcase. You should be able to unfold the pillowcase after you're done cutting and have one long-mirrored mask piece. ***Insert Time Lapse or Video of Cutting out the Template***

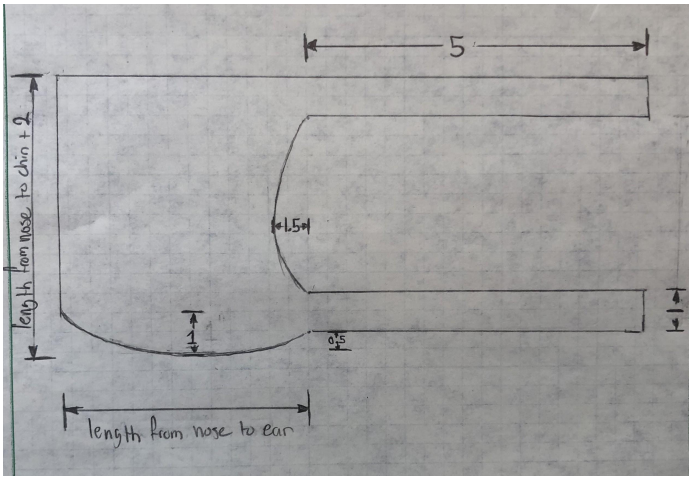
Ok so now that we have that done, next you're going to need to get your hair ties and make the straps of the mask. With the small piece of fabric at the end of the mask, tie the mask to the hair ties at the four contact points. Next tie another piece of fabric to the hair tie in line with the piece you just tied. Repeat for all of the hair-ties.

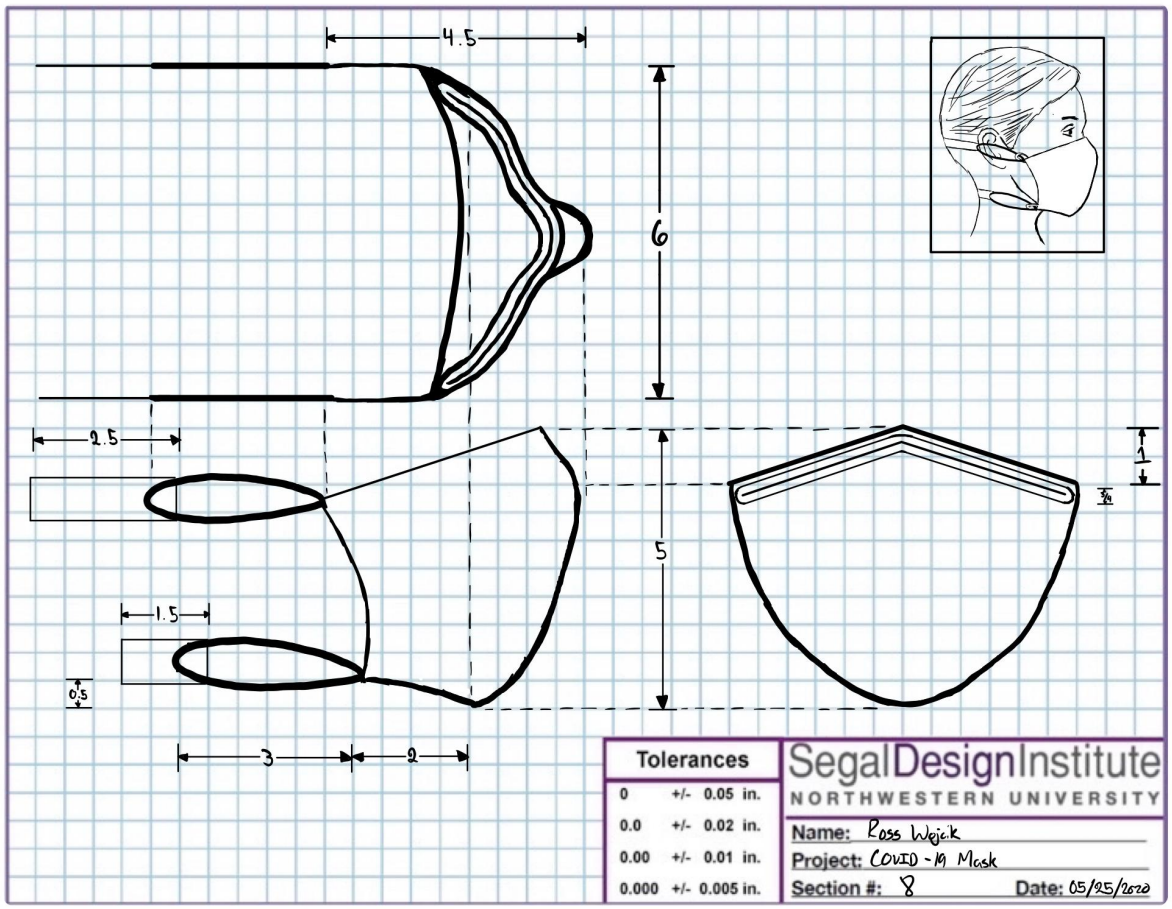
Now unfold the mask and make sure it is laying spread-out on a flat surface. Take your medium-size paper clip and unbend it so that it is roughly straight. You will need the paper clip to be about 5" or 6" so make sure you get the correct size. Next take out the insole from your old tennis shoe and cut a ½ " by 6" section according to the template. If you like, you can make the edges rounded for extra comfort.

Next take the straightened paper clip and place horizontally in the top center of the mask. Place the shoe insole piece over the paper clip, and then fold the extra fabric down over both to complete the layer. At this point, take your tape and seal up the layer so that it doesn't move. Now you can staple the layer together, or if you'd like, just leave the tape on.

And that's it. Take your completed mask and perform a test fit. Mold the paper-clip wires around the curvature of your face so that it sits snug and tight. Pull one set of straps around your head, and, making sure that it's tight, tie the fabric strips together in the back. Do the same for the other pair of straps. Now you have a fully completed and ready-to-use DIY mask.

Pictures


5
length from nose to chin + 2
1.5
1
0.5
length from nose to ear


4.5
6
2.5
5
1
1.5
0.5
3
2
Tolerances
0 +/- 0.05 in.
0.0 +/- 0.02 in.
0.00 +/- 0.01 in.
0.000 +/- 0.005 in.
SegalDesignInstitute
NORTHWESTERN UNIVERSITY
Name: Ross Wojcik
Project: COVID-19 Mask
Section #: 8
Date: 05/25/2020

Appendix G: Instructions for Use

Wearing the Mask

1. Use both hands to hold the bottom strap (Figure 1).
2. Pull the strap over your head and attach it to the back of your neck (Figure 2).
3. Use both hands to hold the top strap
4. Pull the strap over your and attach it to the top of your ears (Figure 3).
5. Bend the top section of the mask to fit your nose (Figure 4). Make sure that the mask is sealed tightly and air is not escaping from the sides.

Disinfecting the Mask

It is recommended to build multiple masks so you have other masks to use while disinfecting the mask.

To disinfect the mask:

1. Leave the mask out in a dry isolated space for 3-4 days (Figure 5). You can rotate 3-4 masks so a mask is available daily.

Appendix H: Design Review Summary

On May 22, we presented a Design Review over Zoom to Group 2, Professors Lake and Gaipa, and a Segal Shop professional. After we presented a short overview of our results from the mockups and our design for the prototype, our audience had the opportunity to ask questions and provide feedback. We asked them to consider its strengths and weaknesses, as well as potential areas of improvement.

We categorized their feedback in the first table below and discussed how we plan to implement their advice in the second table. With multiple perspectives in mind, we hope to develop the most comprehensive design.

Results of the Design Review

Reviewers Like	Reviewers Dislike	Modifications to be made	Other
MASK COMPONENTS Double-strap design Elastic attached to straps Foot insole as cushion material IMPLEMENTATION At-home instructions manual	MATERIALS Tissue paper against face Sewing Tie straps Potential contamination from used bedsheets or kitchen towels People may not be willing to cut up shoe insoles, insoles may be used Buying bed sheets PERFORMANCE Fire hazard in performance	Include disinfecting methods in instructions Use staples, adhesive, or pins to close gaps in foot insole Find alternative to sewing: gluing or staples, pins, heavy-duty tape Differentiate from existing masks in instructions, don't claim more than we've tested Consider alternative materials, other than bed sheets, such as blankets	Research more existing products and pit our design against those Find existing solution closest to ours and make sure there's enough distance between it and ours Max time people are willing to spend: 30 min, 10 mins, <60 mins People are willing to wear the mask for <1 hour, 1-2 hours, 45 mins; however long it takes to go to the grocery store https://www.qmask.gov.hk/about, https://www.qmask.gov.hk/static/media/Still%20Image01_Eng.8e8e8ecf.jpg Insultation: rubber or the

	testing Limited durability/reuse Reliability <u>AT-HOME USE</u> Purchased product > complicated DIY		cushion part on old headphones? A copper wire with a plastic coating might be worth checking out - you can get wire like that for like 30 cents/foot at Home Depot.

Implementation of Advice

Advice Given	**Implementation**
How to address the problem of the contaminated bedsheets	There will be instructions on how to wash the bedsheets before using it to make the mask in the construction instructions
We should instruct users on how to disinfect the masks	We will include guidelines for disinfection in the instructions for use (leaving it on a dry, isolated place for 3-4 days)
Users might have difficulty sewing or creating the product themselves. Would it be possible to create a company for it?	We have decided that this will distance us from our goal of a DIY product so we will not implement this advice.
Elastic material might be better for the straps of the mask because it will fit better around the user's head.	We will look into elastic materials and consider if it will be worth the added trouble of having the strap being a different material.