

ABSTRACT

Due to the current global pandemic, the demand for efficient respirator masks that protect from airborne particles and diseases, such as Covid-19, is at an all time high. This pandemic has changed the world yet again, and the manufacturing and demand of masks will be abundant over the next 3-year course. Consumers expect the masks available to protect from Covid-19, filtrate particles at a 95% or more equivalent rate, fit properly, be low cost and affordable, and be breathable. Currently, respirator masks are being worn for consecutive hours of the day in the workforce and throughout everyday tasks and recreational activities, like this one in Figure 1. The design team is pairing with Parkview Health to innovate an affordable respirator mask with a detachable, cleanable, and reusable filter that innovates a comfortable fit, safe filtration rates, breathable material, long life, ease of manufacture and application processes, while meeting precise safety specifications. The design team created prototypes of different respirator mask designs to meet consumer needs and target safety specifications. The team predicts the product will enhance comfort and safe filtration rates for wearers and can be used in the near future to protect from Covid-19.



Figure 1: Current Mask Example

CUSTOMER NEEDS/SPECS

Parkview Mirro Center is looking for a reusable and low-cost respirator mask for all day use. The mask should be comfortable, have replaceable filters and function similar to an M-95 grade mask. Using these needs, the team created a list of specifications in Table 1.

Table 1: Respirator Mask Target Specifications

Customer Specifications

Protects from COVID-19	Easily take full breaths
Mask is airtight fit	Reusable
Similar to N-95 mask	Stays on properly
Fits most people properly	Material is manipulated
Detachable and Changeable filter	Mask is adjustable
Overall affordable and low cost	Mask last a long time integrally

DESIGN CONCEPTS

Several concepts were sketched out to illustrate team thoughts for the mask design. Figures 2-4 show ideas.

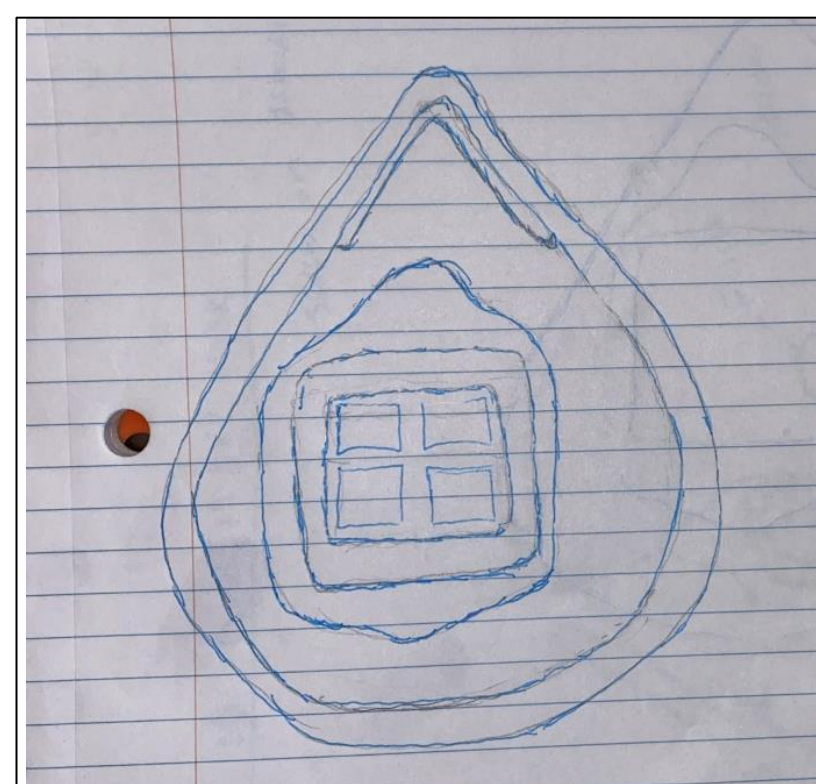


Figure 2: Concept #1

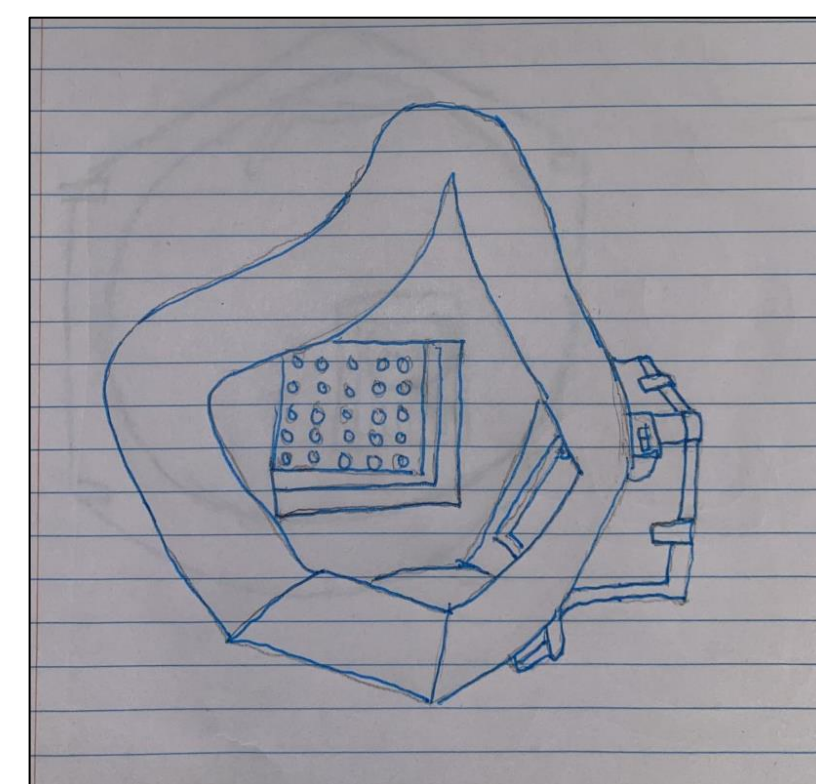


Figure 3: Concept #2

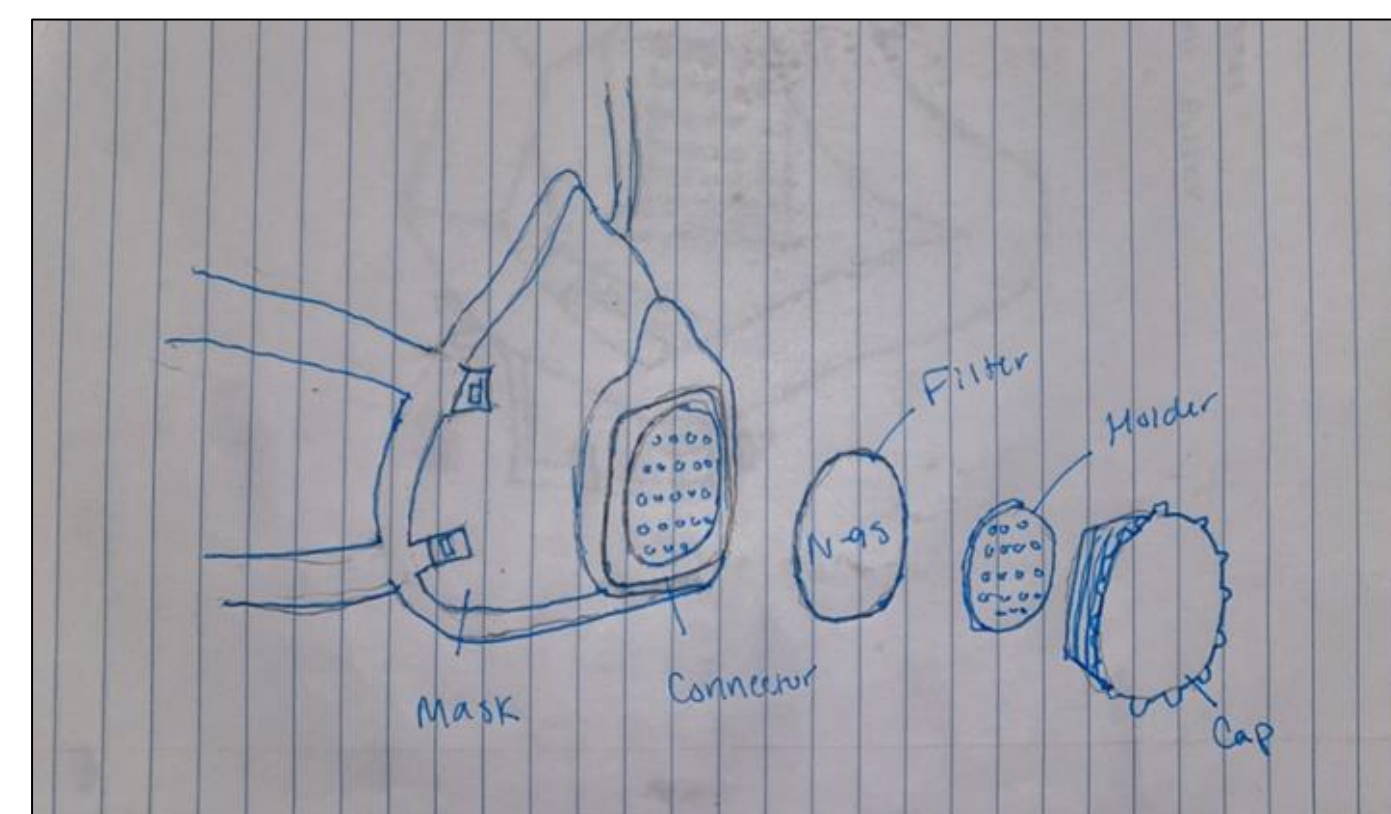


Figure 4: Concept #3

ITERATIONS/TESTING

The first design for the mask can be seen in Figure 5. In essence, this first design was a version with magnets to attach the cap to the body, and a version that use a clip mechanism. Some issues were that the attachments were blocky, and the design was far too large, as shown in test results, Figure 6. This first prototype was printed in house

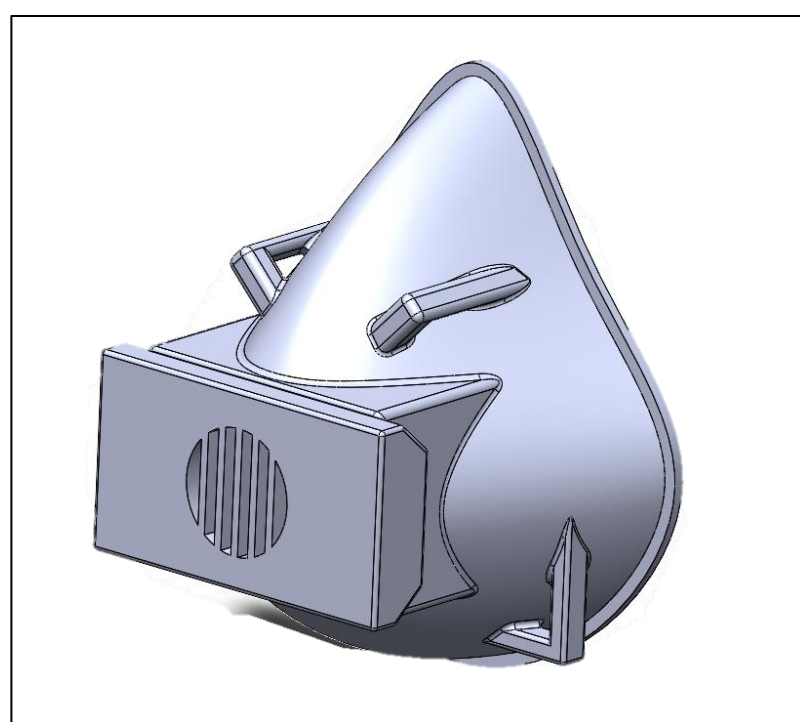


Figure 5: Initial Design - CAD



Figure 6: Initial Design - Printed

utilizing Trine's lab facilities. The design was visually accurate but was too big for most faces. The second design made changes to the scale, where it was scaled down to 0.75 the original size and made the attachment pieces round. Figures 7 and 8 show the CAD revisions and the 3D printed version. The size ended up just slightly small, and the clip design was not ideal at the smaller size.

DESIGN ITERATIONS/TESTING

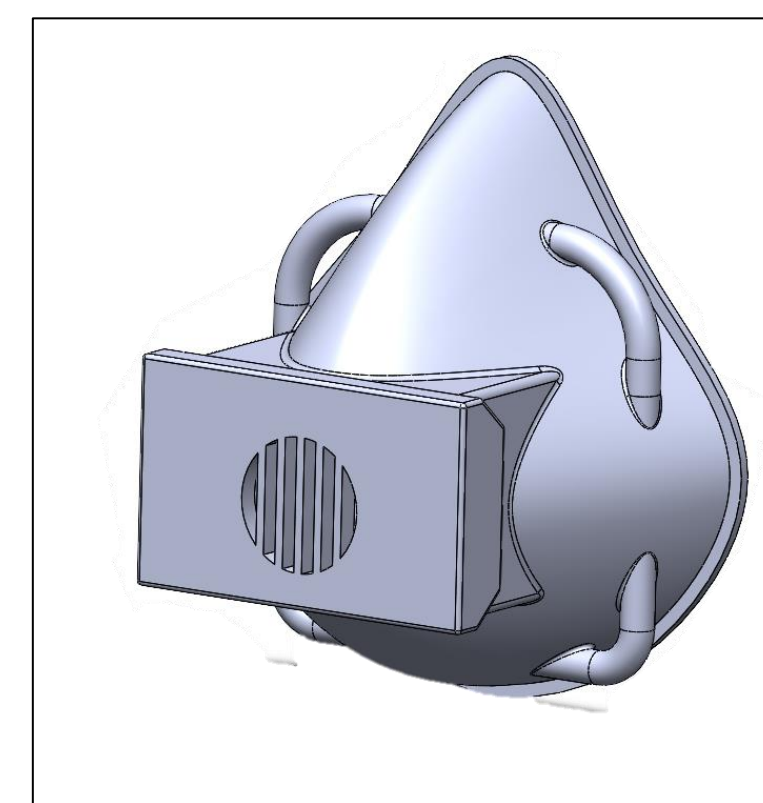


Figure 7: Revision #1 - CAD



Figure 8: Second Design - Printed

The final design iteration increased the size slightly to 0.8 scale. Also, the clip design was changed so that the cover hooked into an indent on the body of the mask. Lastly, a seal was designed that glues onto the outer rim of the body, making it a 3-part assembly. See Figures 9 and 10.

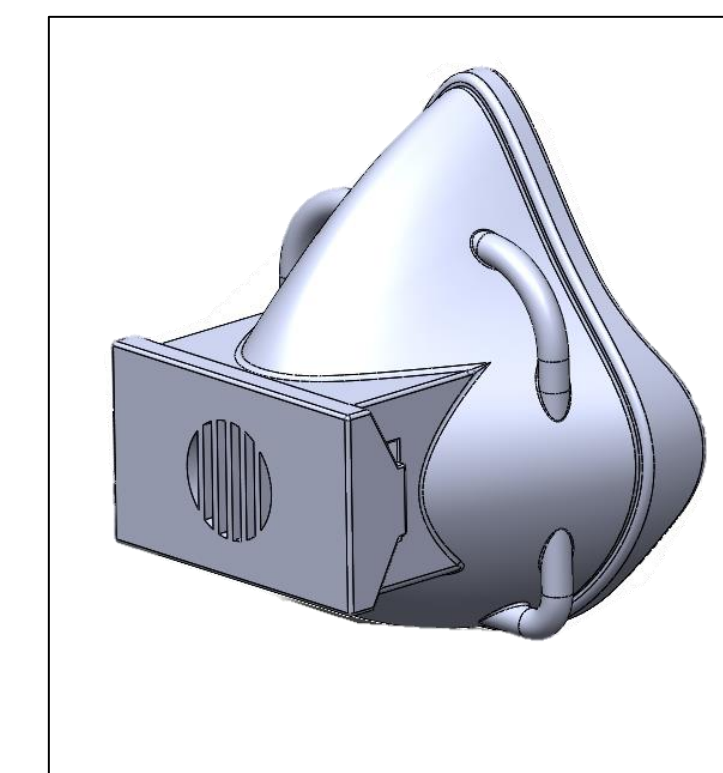


Figure 9: Revision #2 CAD Model



Figure 10: Final Design #1 3D Printed w/seal

The team made some observations about the prototypes at each stage of the testing process. First, the mask material was sturdy and durable. In the first iteration, the contact points for the strapping mechanism were sharply produced. The filter shape and orientation suited the mask's filter positioning location, and the design was produced exactly as intended. Finally, the 360-degree seal flap was sharply produced. In contrast to the positive notes, there were many concerns as well. Leakage points around the cheeks, chin, and jaw were clearly visible. The fixation points for the strapping mechanism were deemed to be un-aesthetically pleasing. 3D printing with the available equipment was unable to produce efficient quality, sharp, clean, smooth edges for the snap-fit filter. The team thinks these shortcomings can be overcome, however, individuals with home-based printers may be challenged with getting the needed quality of print required. This is one area that would require additional iterations and testing to resolve effectively.

FINAL DESIGN

Figures 11 and 12 show the 3D final design inside and worn by a team member. There are flexible enough materials to make a seal, so that was the focus of the last revision. The size was dialed in, and this design can be adjusted to be bigger or smaller according to the person.

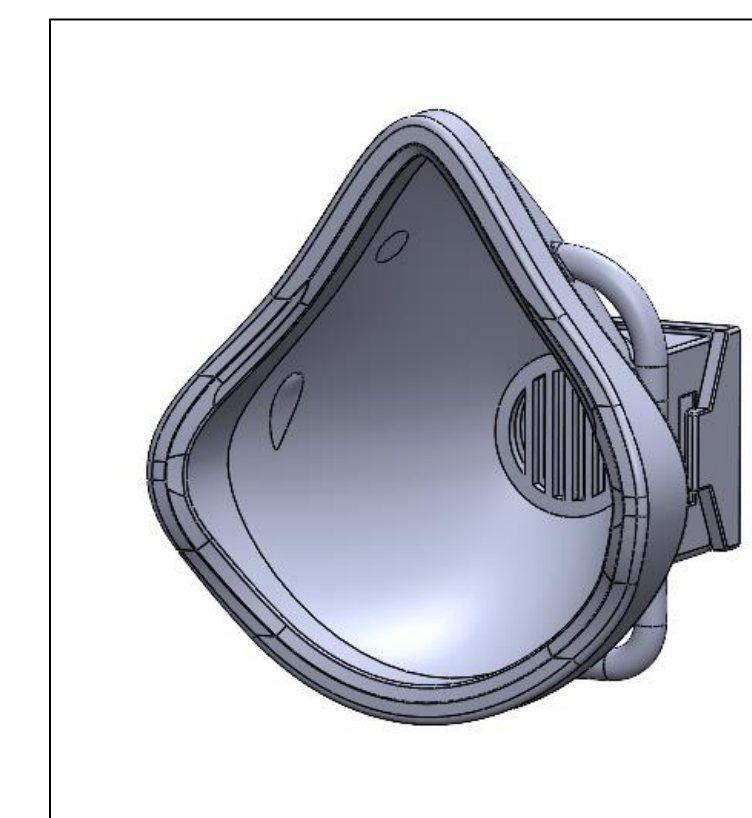


Figure 11: Final Design



Figure 12: Design with Straps

CONCLUSION

The team has designed a functional 3D printed respirator mask in response to COVID-19 in compliance with the needs and specifications set by the Parkview Mirro Center. During the different phases, the team has done research and design work to find the best materials and best design to create a mask for the response of the covid virus. The overall design of the mask allows for a sleek look and is able to be reused. The mask is low cost and helps protect the user from outside particles.

LESSONS LEARNED

Throughout this project, the team learned:

- Ability to conceptualize and break down a primary challenge or proposed issue into smaller subcomponents.
- How to work collectively alongside peer engineers to produce solutions to projects like what is done in the work world.
- The importance of time management

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