Prospectus

Novel Wearable Air Filtration System
(Technical Topic)

SCOT Design of Face Coverings for the Public
(STS Topic)

By

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

The novel coronavirus outbreak, SARS-CoV-2, referred to as the Coronavirus Disease 2019 (COVID-19), was first reported in Wuhan, China, in December 2019 and quickly spread to every country of the world (Dey et al., 2020). It became a public health emergency of international concern on 30th January, 2020, and a global health pandemic by the World Health Organization (WHO) on 11th March, 2020 (Balkhair, 2020). This disease infects people of all ages and races. However, older people (40 years and above) and individuals with underlying medical conditions (such as cardiovascular disease, diabetes, chronic respiratory disease, cancer etc.) are more vulnerable and may get worse because of its deadly complications, most significantly, multiple organ failure (Ademiluyi et al., 2020). To date, the outbreak has escalated to over 45.9 million cases, with about 1.2 million deaths being confirmed and reported globally *(Johns Hopkins University & Medicine*, 2020). During infection, "COVID-19 main protease and spike glycoprotein binds directly to Angiotensin-converting Enzyme 2 (ACE2) receptor of the human host cells, most especially in the lungs where it replicates and causes respiratory infections" (Wan et al., 2020).

However, at present, there are no universally recommended or clinically approved vaccines or specific therapeutic drugs available to provide immunity to the COVID-19 virus (Li et al., 2020). Thus, health officials and institutions have instituted health guidelines, one of which is for individuals to wear face masks in public to help minimize transmission. However, COVID-19 cases continue to increase.

That is why my team is designing an improved and novel wearable filtration device that will lower the transmission of COVID-19. For our technical project to help lower COVID-19 transmissions, the social factors need to be considered for the design process, which includes

social group ideas and concerns. Therefore, by combining the technical and social aspects of the problem, individuals can low the transmission and infection rate of COVID-19 and thus allow individuals to get back to a sense of normalcy. If we do not, we stand to lose many of the freedoms we enjoy pre-pandemic along with putting more stress on front-line workers and hospitals.

To effectively decrease the transmission rate of COVID-19, one must consider both technological and social factors. Below, I outline a technical process for designing a wearable filtration device to increase users' filtration rate and comfortability. Next, I will dive into the Science, Technology, and Society (STS) framework of Social Construction of Technology (SCOT) to analyze how social groups' ideas and concerns influence the design process and why certain design aspects succeed in the marketplace.

Technical Research Problem

Face masks have been around for centuries. Their use has increased within the last serval decades due to several outbreaks of infectious diseases (such as the flu and other respiratory viruses) and the rise of smog from modern industry. The mask's material has also continued to evolve to more effectively filter viruses and pollution (*Global Times*, 2020). COVID-19 spreads from person to person, including respiratory droplets, when the infected person coughs, sneezes, talks, or touches their face and eyes (Singhal, 2020). Thus, face masks have become a critical factor in limiting the transmission and infection rate of COVID-19 since individuals cannot stay in isolation forever, and social distance cannot always be achieved. Another critical factor for individuals to wear face masks is that the incubation period between the onset of infection and the appearance of the first symptom of the disease. The COVID-19 incubation period is typically around 5-6 days (ranging from 0-14 days). Also, COVID-19 is most contagious during the first

three days after the onset of symptoms, and transmission may occur even during pre-symptomatic or asymptomatic stages, making it an 'invisible enemy,' allowing each infected person to potentially infect several others (Dey et al., 2020).

The face mask's current technology includes fabric masks (such as cotton), N95 masks, and surgical masks. With the resource shortage, many individuals are simply wearing 100% cotton masks. Some have managed to acquire and chose to wear N95 respirators, and they contain a one-way valve that releases unfiltered air when the user exhales. However, the N95 mask only blocks 95% of incoming particles, and the one-way valve does not prevent the spread of the virus if the user is infected. Also, N95 fitting is highly tight to limit particle entrance; however, that aspect increases nose and mouth temperatures and irritates some users (Qian et al., 1998). In addition, Health intuitions like the Center for Disease Control and Prevention (CDC) do not recommend that the general public wear N95 respirators citing that they are critical supplies that must be reserved for health care workers and other medical first responders (*CDC*, 2020). Thus, leaving the public with few options and mainly having to use low-quality masks like fabric masks (such as cotton), which only fiber about 10% of incoming air (Konda et al., 2020). Another option is typical surgical masks, which only filter about 85%. That is due to the material and their loose fit; thus, it does not filter or block tiny particles in the air that coughs, sneezes may transmit. Finally, manufacturers label them as disposable, meaning they are not intended to be used more than once (*Center for Devices and Radiological Health*, 2020; Rengasamy et al., 2009). Therefore, there are many limitations to current designs and have room for improvement. Suppose that these limitations, such as filtration rates and comfortably, are not addressed. In that case, these aspects could decrease the number of individuals who want to wear

a mask, leading to increases in transmission rates and the number of COVID-19 cases and increasing the load on hospital capacities and resources.

This project aims to design and optimize a powered wearable air purification system in terms of filtration effectiveness and comfortability to overcome the current hurdles of wearing a mask. To achieve this challenge, the team will use existing components and 3D printed components and design a process orientated around the capability of mass production. The tasks the team will tackle: first, is to determine a design and create a prototype of the reliable apparatus. That includes finding a filter that matches or exceeds current filtration rates of 95% (like a 3M 2091 P100 filter or a high-efficiency particulate air (HEPA) filter). Determine the optimum computer fans that can overcome the pressure-resistant of the filter. Also, finding a face shield that provides clear visibility for the user and 3D printing components such as connectors and clips will be used to mount all components onto a standard baseball cap. Second, we will be validating the precision and accuracy of our prototype filtration using tests like the ones performed on current designs, such as a smoke test. Third, to validate the apparatus level of comfort when the user is wearing it, this will be done using categorize tests to assess user review while wearing the apparatus and perform some daily tasks.

Ultimately, the goal to provide the public with an affordable alternative to maintaining low and/or further decrease the incidents of COVID-19 transmissions and infections while also improving respiratory health.

STS Research Problem

As the infection rate of positive COVID-19 cases continues to increase and with no sign of an effective vaccine in the coming months, the need for effective face masks and respirators will also increase. Therefore, individuals will rely increasingly on manufacturers like Bilio to

create better face mask design concepts that reflect relevant social groups (i.e. stakeholders). While the face mask materials have continued to evolve for better filtration, the face mask design process has not changed since the 19th century (*Global Times*, 2020). Some might argue that the dominant design process for face masks is in use because it the "best" in an objective sense in terms of its effectiveness at preventing the spread of pathogens.

However, certain ideas and concerns of the relevant stakeholders (like users, health professionals, and designers) play a role in the design process. If we continue to think about the face mask design process's current approach only, we will not understand the design process and the social components in the design process. But, if we examine the influences of the ideas and concerns of stakeholders, which play a role, we will have a better understanding of the design process's nature. I argue that the design process is socially constructed, and the ideas and concerns of relevant stakeholders play a role in shaping the design process. I argue that the dominating design process for face masks in use is socially constructed because several influential, relevant stakeholders thought its design addressed their needs and concerns better than other competing design concepts; these concerns included filtration efficiency, comfort, and substantiality.

To frame my argument, I will draw on the STS theory known as SCOT, which examines how technology does not determine human action, but that rather, human action shapes technology and analyzes the causes of technological failures or successes (Elle et al., 2010). Ultimately, the SCOT theory will allow the reader to understand the design process and why specific designs go to the market. Specifically, I will analyze a case study performed by NPR on a company named Bilio, started by two brothers who are long-time designers but are now trying to design a face mask (Blair & Gregory, 2020). Initially, when the pandemic hit, 14 designers of

the company crafted a design process to create a mask that would fit well, be reusable and durable, and incorporate advanced textile technology. Their first approach was to use the "cut and sew" approach because they believed the results with knitting are infinitely better at creating "uninterrupted surfaces" and "transitions" (Blair & Gregory, 2020). They also used a process called zonal engineered knitting, in the case of the mask, uses facial sizing data to inform the design. The designers were also concerned about sustainability, meaning they only knit what they need and use recycled material when possible, which is different from a traditional die-cut and sew approach. However, their design process was also influenced by other stakeholders, such as health professionals, because their concerns were how well a mask protects the wearer from inhaling particles that may carry the pathogen. Bilio also uses customer testing and feedback to refine their face mask design concept. The users of face masks are probably the largest influencers for the design process because they ultimately determine whether their product will succeed in the marketplace. They are concerned about breathability, comfort, adapting the mask to different climates, and sizing (Blair & Gregory, 2020). Also, the designers were also learning throughout the process that users' ideas and concerns constantly change. For example, originally, users wanted a tight seal, but now they want a loose fit so they can be comfortable. Therefore, this coronavirus challenge of developing an optimal face mask design process is a moving target and evolves over time.

Conclusion

In this paper, the technical and social solutions address the problem with the current technology that is used by millions of individuals trying to protect loved ones and themselves from infection and highlight the ways a user's values and beliefs shape what designers and engineers envision for a face mask design, but those creations can end up being the downfall of a

particular technology and sometimes leading to many iterations of a design. My team proposes designing a novel wearable filtration device that incorporates widely available and inexpensive components into a single apparatus that provides superior filtration and comfortability as an adequate replacement for the current personal protective equipment (PPE) apparatus. We will also analyze the filtration system performance by performing consumer feedback and safety performance testing, thus leading to several iterations of the design to best optimize it for the user. The SCOT analysis will help to broaden our understanding of how the social groups' (the stakeholders) ideas and concerns have technical implications and social consequences.

Therefore, the ultimate goal of this technical report will help lower the COVID-19 transmission between individuals. The STS report will shed light on whether the stakeholder's ideas and concerns affect the design process and whether certain ideas succeed or fail in the marketplace if someone does not consider certain social groups during the design process.

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