QFD Submission

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SYDE 161

Professor Matt Borland

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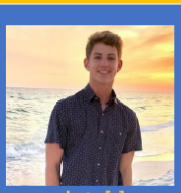
Situation Impact Statement

Design a DIY cloth mask from household materials to be used by 17-25-year-old Canadians at home who do not have the means or time to purchase a tailored mask, or have issues with commercially available masks to prevent the spread of COVID-19 in both indoor and outdoor environments that does not decrease the user's speech volume by more than 10 decibels, does not fog up glasses more than once an hour, does not irritate the ears, and can be washed easily using a washing machine or by hand.

Persona

<table>
<tr><th>Matty B. Jr.</th><th colspan="3">USER STORY</th></tr>
<tr><td> 
photo [1]</td><td colspan="3">Matty is a first-year student studying at the University of Waterloo. Sensitive yet thoughtful, optimistic but calculated, all his peers view him as the ideal engineering student. He is often surrounded by friends and often seen engaging in the most intriguing conversations while rushing to class. Whenever a new fashion trend blows up, Matty is the first to jump onto the bandwagon. Wearing dated clothing is one of Matty's biggest pet peeves. He also loves sharing his musical talents, whether its casual humming in the elevator or strumming his guitar during floor gatherings in CMH. Although he's mostly concentrated on his studies and music, he also has a habit of fidgeting and jittering. He cannot stand long lectures and needs to get out and exercise at least three times a week. Being an engineering student, Matty is as efficient as engineering students come, and becomes easily irritated when spending time on things other than school, music, and friends (this includes laundry). Being a little bit of a clean freak, he keeps his meals outside of his dorm, and often outside of CMH as he loves exploring various restaurants in the vicinity due to his loathing of the mundane cafeteria options.</td></tr>
<tr><th>INFO</th><th>GOALS</th><th>NEEDS</th><th>FRUSTRATIONS</th></tr>
<tr><td>• Age: 19
• Location: University of Waterloo
• Occupation: Student
• Field of Study: Systems Design Engineering
• Country of Origin: Sweden</td><td>• Go on runs
• Spend less time on unnecessary items
• Performing with his guitar for his floormates
• Eat at a variety of restaurants
• Wear the most stylish outfit</td><td>• Quick to clean and put on
• Breathable
• Effective at filtering in clustered indoor spaces
• Protects his floormates and the restaurant workers
• Can be modifiable to meet the current fashion trend</td><td>• Most masks make the user uncomfortable when exercising
• His floormates and friends are distancing one another to prevent transmission
• His mask gets stained after a restaurant meal and takes too long to clean off</td></tr>
<tr><th>PERSONALITY AND SKILLS</th><th colspan="3">INFLUENCES</th></tr>
<tr><td>• Sensitive
• Analytical
• Extroverted
• Curious
• Active
• Ostentatious</td><td colspan="3"> 
</td></tr>
</table>

QFD Chart

		Who			How																Now	
		Child Mask Wearer	University students		Steps to position on face	Angular misalignment	Bacterial Filtration Efficiency (ASTM F2101)	Fabric Bursting Force (See ASTM D3786)	Time to Air Dry	Steps to Wash	Time glasses are fogged while wearing a mask	Thread count	Strap durability over time	Strap maximum tension	Likelyhood to wear mask in public	Moisture absorption of inner fabric	Average time until ear irritation begins	Maximum fluctuation of distance between face and edges of mask	Average decrease in decibals while speaking when wearing a mask or not	Perceived breathability	3M N95 Mask - No valve	Face shield
					L	L	H	H	L	L	L	H	H	H	H	H	L	L	L	H		
What					steps	deg	%	Pa	hours	steps	unt/hc	TPI	wears	mmHG	%	%	hours	mm	lecibal	%		
Putting on Mask	Easy to position on face	15	0		9	5											5				3	4
	Quick to put on	15	0		9																3	4
Using a Mask in Daily Activities	Filters Aerosols Well	20	25			5	9					9			5	9		9			5	1
	High Durability	0	5				5	9					9	9							5	5
	High level of comfort	30	10		1	1					5	5	5	5	9		9	5	1	5	1	3
	Fits well - stays on	10	10		1	9							5	5			9	9			3	3
	Glasses not fogging	0	10			5					9				1	1		9			2	4
	Good breathability	20	15			1	1					9								9	1	5
	Minimal obstruction when talking	10	10									9							9		2	5
	Aesthetically pleasing	0	15			5					1				9						1	1
Cleaning Mask	Easy to clean	0	10				5		5	9		1				1					1	5 [2]
	Quick to clean	0	5						5	5											1	5 [2]
	Quick to dry	0	5						9	5											1	5
		120	120																			
Importance	Child Mask Wearer				8	8	5	0	0	0	4	16	5	5	10	5	11	11	3	9		
	University Student				1	10	9	1	3	4	4	15	4	4	10	7	5	13	3	5		
Competitors	3M N95 Mask - No valve				7 [3]		95 [4]												12 [5]			
	Face shield				2 [2]		0			5 [2]	0								0			
Target					2	0	99 [6]	7.45x 10^7[7]	2 [8]	3	0	600 [9] [4]	50 [12]	40 [13]	100	575 [14]	10	1	0 [15]	100		
Threshold					3	20	85 [8]	745	10	6	4	96 [10][11]	20 [12]	50	80	288 [14]	4	40	15 [16]	60		

Reasoning Behind Established Target and Threshold Values

1. Thread Count

Our target value for the thread count in cotton is 600 TPI (Threads per Inch). Our value is based on the results from an experiment where the filtration efficiency of the 600TPI cotton had a range of 65% efficiency at <300 nm and a >90% efficiency at >300 nm particles, which is comparable to the filtration efficiency of an N95 surgical mask [6]. Our threshold value for the thread count is 96TPI, which was established based on a study which found that a two-layer cotton fabric of 96TPI achieved a filtration efficiency of 69%, in contrast to an 86TPI fabric achieving an efficiency of 43% [10]. The particles tested were 60-100um, which were of similar size to COVID-19 aerosol particles [11]. The considerable drop between a 96TPI and 86TPI indicates that our threshold value should be 96TPI to avoid further loss of filtration efficacy.

2. Average Decrease in Decibels with Mask

Our target value for maximum decibel reduction is undoubtedly 0. Since the start of the pandemic, approximately 357,000 profoundly deafened Canadians are experiencing social isolation because masks have been compromising their communication options [15]. There is also a higher prevalence in hearing-loss among the elderly (ages 80+). With many deafened patients (many elderly) currently receiving treatment within emergency departments (some even with COVID-19), it is imperative for them to receive clear and accurate medical information while preventing the chance of transmission [5]. Therefore, if the decibel reduction is minimized to 0, those deafened will be relieved of their social barrier, and improve their mental health in highly stressful environments caused by hearing loss [17]. Our threshold value was 15 decibels, which is the slightly above the decibel attenuation of an N95 mask (12 decibels) [11]. We increased the threshold since other studies have shown various cases of masks impairing speech past 12 decibels [16], and since one of our main engineering specifications is higher thread count which acts against this specification. There have also been cases of utilizing smartphones for regular communication due to mask coverings [15]. This affects the efficiency of social interaction, which is not ideal for busy individuals like university students.

3. Strap Maximum Tension

The maximum strap tension value is highly relevant to the comfort of the users. Our target value for mask strap tension is 30 mmHG, and our threshold is 50 mmHG. This value was based off a study done on the effects of strap tension on biomechanical and biomarker responses within the skin [13]. The study used tensions ranging from 34 – 77 mmHG and evaluated this tension against pressure on the cheeks, nose, and relative user comfortability. The highest user comfortability and lowest pressure on the skin and cheek was recorded at relatively lower mmHG values (low 30s to mid 40s) [13]. As the tension increased beyond that range (high 40s to high 70s), there was increased discomfort and pressure on the face. Using this data, we determined our ideal target to be 30 mmHG.

Customer Requirements Justification

Fits well – stays on: This is a moderate priority, as many masks are not made for specific face shapes and this often results in slipping and discomfort.

Glasses not fogging: Lots of university students wear glasses or sunglasses and it can get very frustrating to have your vision blocked when breathing too hard or even doing daily activities and can lead to continuous readjustment of the mask which is important to avoid. Not everyone wears glasses, but for users who do, this can be as important as breathability, if not more, as you are impairing your vision.

Breathability: Masks need to be worn for almost all daily activities, and so easy breathing is necessary. This is a user requirement that is always applicable when wearing a mask and can get very irritating if it is not comfortable, and so it is a high priority.

Minimal obstruction with talking: Students are often communicating with either their professors, peers, or at local dining areas/cafes, so it would be ideal to ensure the mask does not interfere with or limit their ability to do so. Excessive obstruction in talking would likely result in decreased mask usage because it would limit the efficiency of in-class learning, so its importance weighting was established to be relatively high at a 10.

Aesthetically pleasing: A big aspect of campus life for students is being confident in their appearances; if the mask limits this or gives the feeling of "sticking out" in a crowd, students will be more hesitant to use masks when out in public. Having a functional mask with stains or poorly done seams can have a big difference on how the user feels about going outside with the mask on, especially as it is already an adjustment to begin wearing a desk

Quick to dry: The faster the mask dries, the shorter the turnover time to wearing the mask again and the fewer users need to own and keep track of. However, it is not as important as many of the other functional requirements, and slow-drying cloth is not a major source of irritation.

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