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Self-Designed Guidance: Medical Mask Brace Adaptability Improvement Plan

Yupei Kuo[1] and Xing Yang[2,*]

[1]Master Program in Creative Design, Chinese International College, Dhurakij Pundit University, Bangkok 10210, Thailand;

[2]School of Fine Arts and Design, Huizhou University, Huizhou 516007, China.

[*] Corresponding Author: 531062330@qq.com.

Abstract

During the pandemic, wearing medical masks to protect against viruses is a common consensus and regulation in most countries. However, as a universal design, medical masks are challenging to fit with individual faces to avoid the gap for viruses. Moreover, the disposable mask produced mass waste and environmental problems. More importantly, at the beginning of each pandemic, there will be a run on anti-epidemic materials, especially masks. Improving the protective ability of medical masks can effectively alleviate the shortage of masks at the beginning of the pandemic. The aim of this study is to develop an easy self-designed guidance to improve the adaptability of medical mask braces, so as to improve the leakproofness, comfort of medical masks by accessible reuse materials and users. Based on design practice methodology, this research follows the process of product problem definition, design rationalization, prototype development, testing, and verification. The conclusion suggests the designer abandons the completed product design but shares the prototype into the guidance to promote widely pubic benefits. The guidance provides a simple way for the public to produce personal mask braces easily with the reuse of mask ropes. As a feasible, low-cost solution, the flexible prototype of the mask brace enables adaptation to individual needs and functional requirements or to cope with existing site conditions. The coronavirus pandemic looks to ease but is unlikely to be put to an end yet, and no one knows when the new infections will arise. The concern motivates the research to seek solutions and coping mechanisms by design to develop knowledge and know-how relevant to today's situation while also preparing for unexpected challenges.

Keywords

Coronavirus, Mask Brace, Reuse, Self-Designed, Social Design, Sustainable Design.

1. Introduction

The coronavirus pandemic looks to ease but is still unlikely to end, and nobody knows when the new infections will arise. The concern motivates the research to seek solutions and coping mechanisms by design to develop knowledge and know-how relevant to today's situation while also preparing for unexpected challenges.

More importantly, at the beginning of each pandemic, there will be a run on anti-epidemic materials, especially masks. Improving the protective ability of medical masks can effectively alleviate the shortage of masks at the beginning of the pandemic.

Due to the coronavirus pandemic worldwide, the mask occupies a person's face all the time. With these years of propaganda in the World Health Organization (WHO) and the Centers for

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Disease Control and Prevention (CDC) of each country, the public knows and accepts the importance of masks.

The use of masks is part of a comprehensive prevention and control measures package that can restrict the spread of certain respiratory viral diseases. Wearing medical masks can be used to protect healthy persons and prevent onward transmission when in contact with an infected individual. [1]

Correct and consistent mask use is a critical step to prevent getting and spreading viruses. However, the public is accessible to neglect to check whether they are wearing masks correctly to prevent gaps where viruses can enter, such as seamlessly covering the nose and mouth and completely fitting to both sides of the face [2]. However, the mask is not just a cover; the fundamental problem is fitting to avoid the virus from the gap. Unfortunately, the medical mask is a universal design, most consumer-available masks are loose-fitting, and users are challenged to fit with the face to avoid the gap for the virus. In order to solve the problem, the US CDC recommends fabric plus a medical mask or using a "mask brace" to prevent getting and spreading pandemic and suggests people how to improve the fitting of the mask with the face in the guidelines [3]. However, the way of fabric plus medical mask may not be suitable for some areas, such as the area with hot weather that, people are difficult to wear two masks. Therefore, the researcher would like to develop an easy self-designed guidance to improve the adaptability of medical mask braces, so as to improve the leakproofness, comfort of medical masks by accessible reuse materials and users.

2. Literature Review

2.1. Mask Fitting Effect

With these years of Propaganda by WHO and every country's CDC, the public knows and accepts masks' importance. Therefore, correct and consistent mask use is a critical step to prevent getting and spreading viruses. A mask with layers could keep the respiratory droplets and others out and in [3]. Medical masks can be used to protect healthy persons (worn to protect oneself when in contact with an infected individual), source control (worn by an infected individual to prevent onward transmission), or both. (Preparedness, 2020) Masks work best when everyone wears them, but not all masks provide protection. The effectiveness of a mask depends on how well it fits, how well it braces the air, and how many layers it has. [3]

Selecting a correct mask is important; however, correctly wearing the mask is also essential. However, the public is easy to ignore to check if users are wearing a mask correctly. Therefore, the USA CDC guideline suggests that make sure the mask fits snugly against the face, covers the nose and mouth completely, fits snugly against the sides of the face, and does not have gaps. Gaps can let air with respiratory droplets leak in and out around the edges of the mask. The figure 1 shows the gap path of the virus leaking. [3]

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Figure 1: The gap of virus leaking path: gaps around the sides of the face or nose. Source: https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/types-of-masks.html [3].

From the design perspective, the mask is a universal design product for the public, which means that it happens a lot that the mask does not fit the user's face because of size or shape. For the ergonomics causes, the US CDC guideline also points to suggestions to improve the fitting in three ways: the first way is wearing a mask brace or brace on the mask; the second way is to wear one disposable mask underneath a cloth mask with multiple layers of fabric, as shown in the figure 2, and the second mask should push the edges of the inner mask against the face and brace; and the third way is to knot the mask rope like the figure 3 shows. [3]

People wearing two masks is good to increase protection, one medical mask; however, breathing might take more effort. In addition, some people would be challenged to stop wearing the mask because it is uncomfortable and airtight in some situations, such as under hot weather. Therefore, the research aims to design a sustainable mask brace to improve fit and reuse the waste mask ropes. The outcome provides a simple manner for the public to produce mask braces with the reused mask ropes in some conditions that make it difficult to wear two masks.

However, no matter which way people choose to wear, the most critical point is comfortable to wear for a long time; it is necessary to ensure that users have good vision and breathing continuously to obtain the best protection [3]. Otherwise, it is more dangerous if people need to adjust their masks by their hands. Therefore, considering the climate and temperature and the breathing problem, the research would focus on the brace design to make the public group wearing two masks comfortable for a long time in certain areas or conditions.

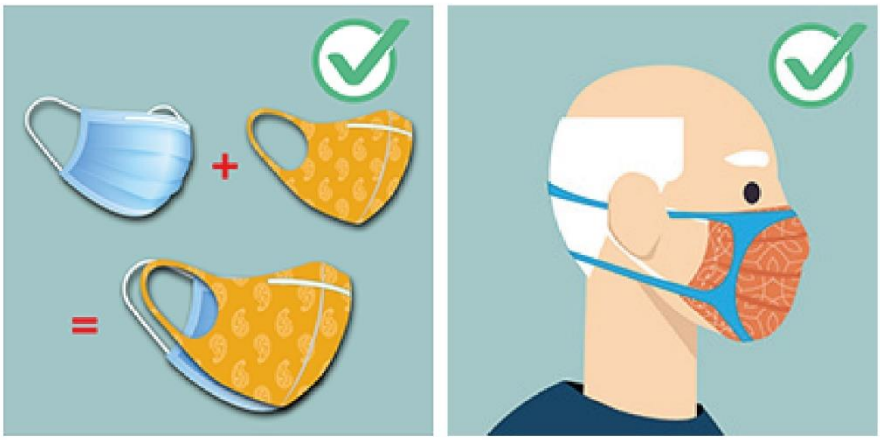

Figure 2: The two ways of improving the fitting.
Source: https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/types-of-masks.html [3].

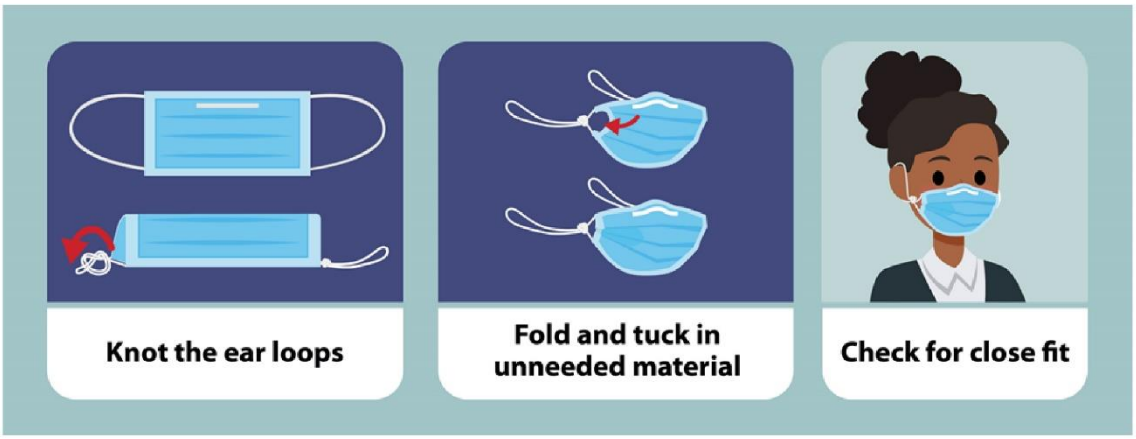

Figure 3: The knot ways of improving the fitting.
Source: https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/types-of-masks.html [3].

2.2. Waste of Masks

Since the pandemic, face masks have been the norm to protect the public, which means thousands of masks are being thrown away everyday. Some experts state their concern that discarded face masks could become a significant hazard to the environment, particularly wild animals and birds. Dumped masks have become a new hazard to the environment since the pandemic, so far to animals. Such animals are susceptible to tangling up in face masks such as Elastic bands, as they can wrap around animals' bodies or beaks and cause choking and other injuries. One such UK incident includes a gull who was found to have a face mask tightly around his legs and causing swelling [4]. In waste mask cases, Royal Society for the Prevention of Cruelty to Animals (RSPCA) encourages people to cut up the disposable gloves and snip the straps on face masks to prevent animals from getting tangled [5]. For the materials, dumped face masks have become a new hazard to the environment and animals; the agency encourages people to dispose of rubbish responsibly, reuse them where possible, or cut them open before

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throwing them away. It inspired the research to involve the mask ropes as materials as part of the design.

In addition, there is an advantage for textile that the cloth could be cleaned by washing or air-drying to inactivate the virus [6]. The project gains the idea to collect the mask ropes to reuse in personal mask bracers for recycle use, and the ropes are easy to wash and disinfect.

2.3. Mask Brace of Commercially Available

Due to the public demand, there is some mask brace for general purchasing. Most braces produce ready-to-wear products with rubber or fabric. However, the common problem is how to fitting to an individual face. For example, the Company "FIX THE MASK" released mask brace by Biocompatible Silicone into three sizes. Customers need to check the personal sizing guide before placing the order, shown in the figure 4. [7]

Figure 4: The face mask brace by FIX THE MASK.
Source: https://www.fixthemask.com/ [7].

It is worth mentioning that 3D printed mask brace. The 3D printed face mask brace is a personalized 3D printed plastic frame contoured to the specific shape of a person's face to improve the seal of surgical or similar face masks, shown in the figure 5. The consumer needs to operate the dedicated face-scanning application to generate a personal 3D face mask brace model to print in the 3D printer and then use band material to hold the brace around the head [8]. There is no charge for the application and the printing cost starts at $1 per mask brace. It needs to be mentioned that some 3D-printed materials may be porous and more difficult to sanitize [8]. Indeed, the 3D mask brace apply advantage in customized to fit with a personal face by 3D scanning. However, there is a problem to promote widely, especially for the elder and low-income groups.

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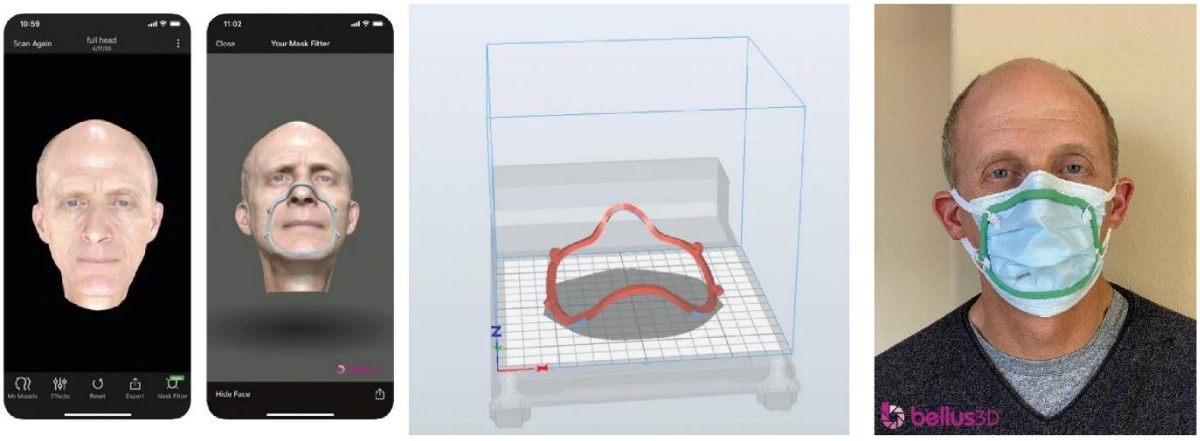

Figure 5: The 3D face mask brace by bellus3D company.
Source: https://www.bellus3d.com/solutions/facemask [8].

3. Methodology

The researcher would like to experiment to explore mask brace prototype by understanding the mask structure and virus leaking path to be involved in a broad range of activities in response to the pandemic by the design practice, supported by experimenting and sharing conditions in daily use and the impact on health services.

The research is practice research in design to explore the ideas from literature reviews to set up the prototype, follows the process of product problem definition, design rationalization, prototype development, testing, and user verification based on design practice methodology [9]. The product problem definition was based on typical methods of designer individual exploring and comparative study review to set up the hypothesis.

"Experience Prototyping" is a form of prototyping that enables designers and users to "experience it themselves" to gain a first-hand appreciation of existing or future conditions through active engagement with prototypes [10]. Design rationalization then used the gathered information to program the design and prototype development.

During the experience prototyping phase, as the designer, the participants will gain first-hand experience in the situations involved and receive a substantial sensory experience and a subjective emotional experience. The research composes the five public users of ages, sex, and sensitive users and two designers to gain feedback by observation during the operation experience and interviews. Implementing it aims to discover the potential product or user experience problems in practical applications, allowing the designer to analyze the product or service from the user's perspective. The prototype and material testing involve application trials, defect detection, and evaluation to determine the suitability of a prototype and material for its designed use. The developed prototype was classified as a flexible, functional brace, tested by users, and eventually upgraded for the guidance for the public to benefit more areas.

4. Design Experiment and Practice

The experimental scene is people wearing two masks, one medical mask and one fabric mask; however, people cannot stop adjusting the mask because it is uncomfortable and airtight in the hot weather. It is good that people try to wear masks correctly to avoid viruses with all the methods but fit different conditions. The experiment would like to design a brace that people can use household tools and materials to produce the brace easily and free. Nevertheless, people spent massive amounts of money and materials during the pandemic. The experiment

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determined the basic medical mask as an experiment item due to the leaking problem relative to other unique masks and the widespread popularity and relatively cheap.

4.1. Structure

The research follows the USA CDC guideline, figure 6(a), as the beginning sample to analyze the structure of the mask brace. First, the research explored the mechanic's structure to predigest into line structure and then drew the 2D pattern as shown in figure 6(b). The research expands from the CDC sample prototype into four hypothesis structures, drawn as shown in the figure 7 [3], and applied with actual flexible materials to test the condition.

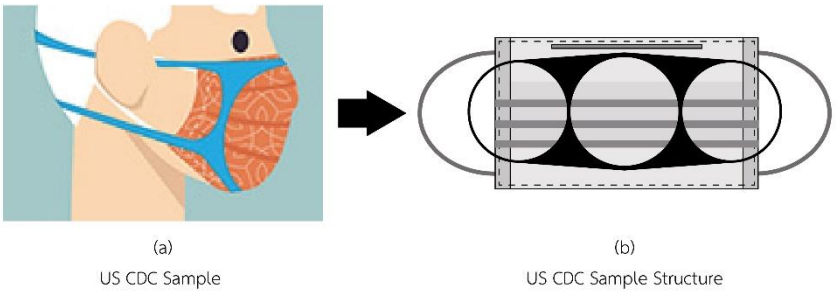

Figure 6: The mask brace prototype structure (b) of CDC sample brace (a).
Source: https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/types-of-masks.html [3].

The research drew the hypothesis line structures and applied them with actual flexible materials to test the effect. The research sorted out the result and hypothesis line structures in the table 1. There are some advantages and disadvantages with the supposed line structures with the actual flexible material to wear. Both the prototypes (1) and (3) fit with a face without a gap, but the prototype (3) could adjust the fit position as an advantage. There is a fitting problem in the prototype (2); therefore, the research adds side structure for the prototype (2) into the prototype (4) to solve the fitting problem. Compare the four structures. The prototype (4) is the best way to fit with the face, but is it essential to use many structures? or waste more materials?

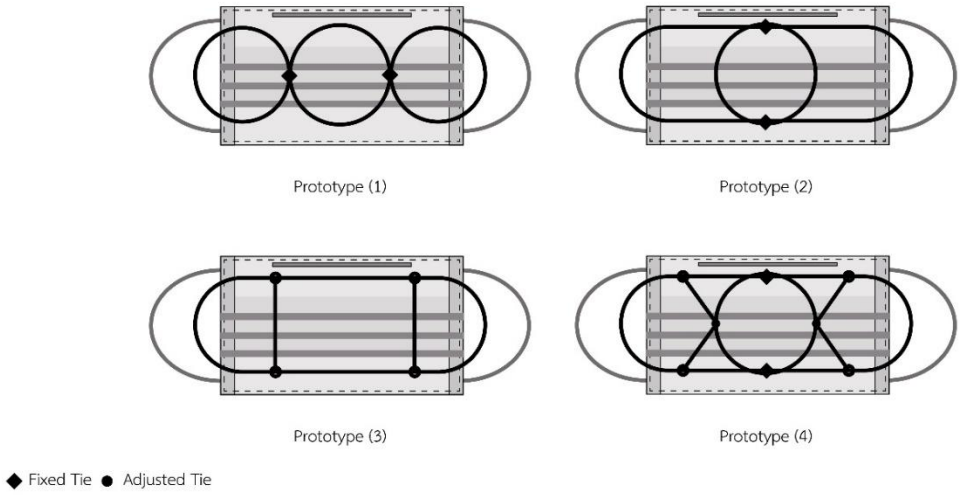

Figure 7: Structures of four mask brace prototypes.

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Table 1: Effect result of each prototype.

	Prototype (1)	Prototype (2)	Prototype (3)	Prototype (4)
Fixed on face	Yes	No	Yes	Yes
Fitting to face	Yes	No	Yes	Yes
Adjustable	Yes	No	No	Yes

4.2. Material

The research set up the position in social design to benefit the low-income groups or goods and materials in limitation. Furthermore, considering the condition limitation, the research applied the material and tools that can be quickly and effectively obtained in daily life, especially reuse materials, which would be easier for the public.

Moreover, coronavirus does not survive for long on clothing, compared to hard surfaces, and exposing the virus to heat may shorten its life according to related researches. For example, a published study found that coronavirus was detectable on fabric at room temperature for up to two days, compared to seven days for plastic and metal. However, when exposed to high heat, the virus became inactive within five minutes [6]. In addition, there is an advantage for textile that the cloth could be clean by washing; consider using bleach or color-safe bleach, which may inactivate the virus if it is present. Moreover, placing the cleaned clothing into the dryer, drying a load of laundry thoroughly in the dryer, rather than air-drying, could be another way to inactivate the virus [11].

The research collected cloth band, elastic band, and rubber band applied with the test structure in practical application and listed the result in the table 2. The experiment results that the cloth band with the advantage of collecting quickly, but without the flexible function, it would because a problem that the brace could not be fixed stable on the face. The rubber band is also a kind of household material which easy to collect. Some online resources teach the public how to DIY mask brace with rubber [12], similar to the prototype (1)[13]. The rubber band brace is easy to fix on the face with the experiment. However, due to the material flexibility being too strong at first, the user is uncomfortable, especially in the ears. Compared to cloth and rubber bands, the elastic band is more suitable for users: firstly, with flexible to fix on the face, and the material and width are more comfortable for users. The elastic band is also a common household material. In addition, the medical rope is also a kind of elastic band material.

Considering the previous study about mask pollution and waste, the research explores the possibility of sustainable design to reduce the pollution and waste of medical masks. Therefore, the research decided to add the mask ropes to the list in the table 2. Compare the materials' practical results and consider reducing the pollution and waste of masks. The researchers decided to set up the mask rope as the primary material and modify the test structure to fit the mask rope's fixed length to reduce mask waste.

Table 2: Result of Each Material in Prototype

	Cloth Bands	Elastic Bands	Rubber Bands	Mask Ropes
Household material	Yes	Yes	Yes	Yes
Flexible	No	Yes	No	Yes
Result	With the fixed problem on the face	No length can adjust better to fix	Uncomfortable for ears The flexible is too strong to control	Length fixed better to fix
Clean	Wash and dry	Wash and dry	No enough data support	Wash and dry

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4.3. Result and Discussion

Considering the user experience, the availability of materials and the ease of cleaning, the research decided to combine the prototype (3) with the reuse mask rope. Since the fixed length of the mask rope, the line structure needs to be modified. The research collected mask ropes tested the knot, and connected them to complete the prototype structure, shown in the figure 8. The gathered mask rope length is about 16mm to 17mm, and choose the most straightforward way to tie the ropes. The prototype (3-1) uses three mask ropes to complete the basic circle and two for adjusting the brace. Furthermore, the prototype (3-2) uses four ropes to complete the basic circle and two ropes as an adjusted brace—the different amounts of ropes for users to choose from with personal face size and materials condition.

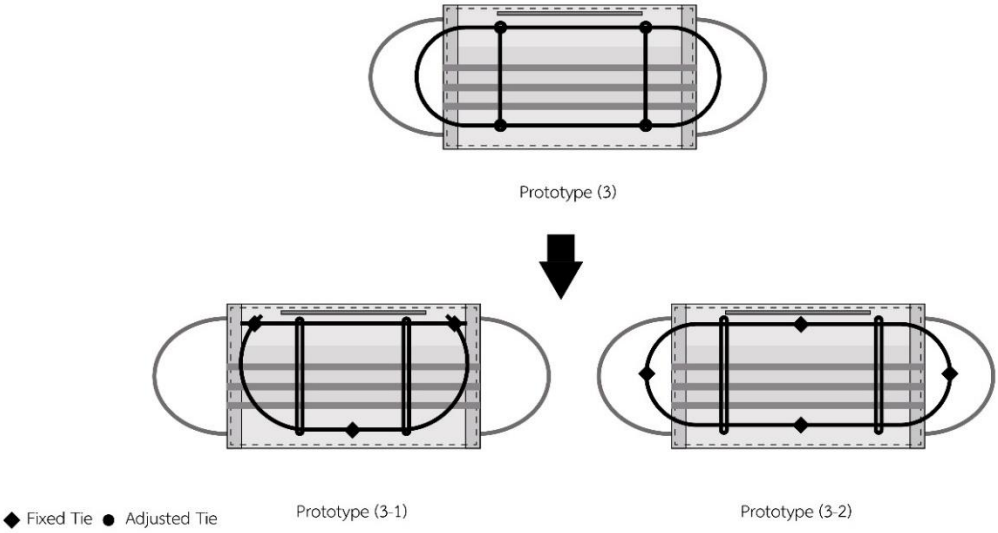

Figure 8: The prototype structures extended from Prototype (3).

As a practical research, the researcher recorded the experiment process from the collecting mask ropes to tie the ropes in knots, and the user presented the wearing process, shown in the figure 9, 10, and 11.

Figure 9: The collecting mask ropes.

Figure 10: The steps of wearing the mask brace.

Figure 11: The mask brace presentation by user.

To benefit to public broader, the research would like to expand the aspect from product design to social design. Therefore, the research outcome is not just a product design, a mask brace prototype, but a guidance for the public to improve the fitting and making by reusing waste mask ropes. Therefore, the research draws each step of producing the mask brace, as shown in figure 12 with description.

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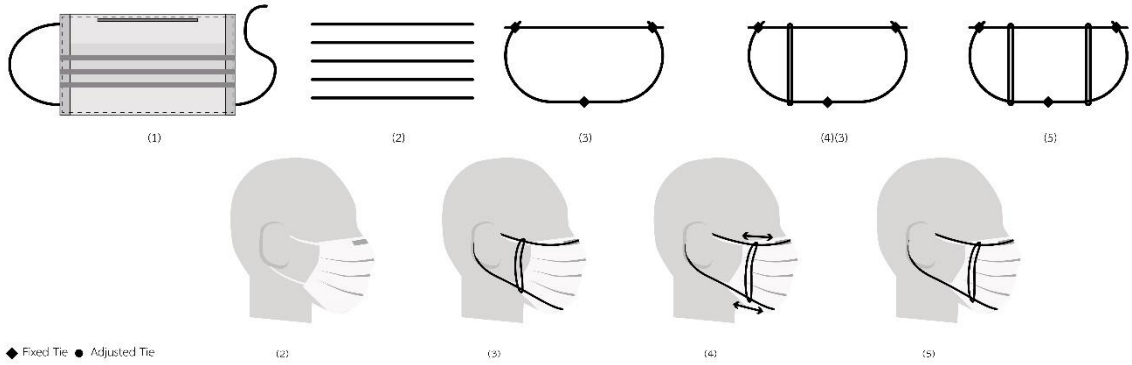

Figure 12: The steps of making a brace by reusing mask ropes:
(1) to cut off the mask ropes from the waste mask and then clean and dry them;
(2) to collect five or six clean mask ropes;
(3) to use 3 or 4 ropes to tie fixed circle by personal condition;
(4) to use 1 rope ties an unfixed knot across the circle on one side;
(5) to use another rope to tie an unfixed knot across the circle on another side;
(6) to wear the mask correctly follows by the CDC guidelines;
(7) to wear the mask brace;
(8) to adjusted the unfixed knot to fit with the personal face; and
(9) to check the comfort and fitting by the CDC guidelines.

To reach the objectives to benefit more people and areas, the research suggests a different way to present the guilds in a free physical booklet and film tutorial. The company "FIX THE MASK" sells the product and also releases a free DIY version with a Video tutorial to teach the public cutting rubber sheet to gain a simple rubber mask brace [7].

5. Conclusion

During the coronavirus pandemic worldwide, wearing a medical mask is essential to protect ourselves. However, the mask is a universal design and challenging to fit with an individual face to avoid the gap for the virus. On the other hand, the disposable mask also produces mass waste and environmental problems.

The aim of this study is to develop an easy operate self-designed guidance to improve the adaptability of medical mask braces, so as to improve the leakproofness, comfort of medical masks by accessible reuse materials and users. The project outcome provides a simple brace design to produce mask braces easily with the reuse of mask ropes and sustainable design principles. During the prototype design phase, the study analyzed the structure to build the prototype and applied it in actual practice to improve. The study also tested the prototype with different household materials.

There are no unique materials or high technology in this project. The objectives of the material and technology are to gain the needs efficiently and quickly in daily life. Therefore, it is better to acquire the material from daily or household materials. It would be easier for the public to set up household tools or handy ways to fit with the possible conditions of the users. In addition, the study's outcome is not just a product design, a mask brace prototype, but a guidance for the public to improve the fit and making by reusing waste mask ropes. To reach the objectives to benefit more people and areas, the users of experience feedback is significantly essential when improving a guidance design for the further phase.

The coronavirus disease pandemic looks to ease but is unlikely to be put to an end yet, and no one knows when the new infections will arise. The concern motivates the research to seek solutions and coping mechanisms by design to develop knowledge and know-how relevant to today's situation while also preparing for unexpected challenges.

Acknowledgements

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