User Experience of Essential Worker Wearing a Face Shield While Working During Pandemic in Malaysia.

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Abstract. This paper presented the process of producing a face shield and the user experience of face shield wearer. Traced from Wuhan, China a severe acute respiratory syndrome coronavirus 2 known as COVID-19 has spread to the whole world and being declared by World Health Organization (WHO) as global pandemic March 2020. This virus is highly contagious and can be transmitted via respiratory droplet and physical contact with the virus carrier forcing everybody to wear a facemask. With the emerging Delta variant, all essential workers are forced to wear extra protection during their daily routine work. A face shield produces by addictive manufacturing, or three-dimensional (3D) printing was introduced as to be alternatives production to cope with the shortage of personal protective equipment (PPE) component that being faced by essential worker all around the world. This face shield was printed by fused deposition modelling (FDM) printer using poly-lactic acid (PLA) as material. Attached to a thin clear Polyvinyl Chloride (PVC) sheet, this face shield was given to 3 front-liners and 4 essential workers to be ware during their daily routine work. For this study, their feedback of using the face shield is taken and recorded via conversation during think aloud session. The outcome is being presented in this paper as this face shield is proven to be effective and feasible to be wear by frontliners and essential workers in Malaysia during this pandemic era.

Keywords: covid-19, face shield, user experience, 3d printing

1 Introduction

1.1 Background

A series of an unknown acute respiratory tract infection was reported in Wuhan City Hubei Province back on 12 December 2019. Later known as Corona Disease 2019 (Covid-19), which was traced back from the Hunan South China Seafood Market [Guo, Cao, Hong et al. 2019]. On 11 March 2020, the World Health Organization (WHO) declared this disease as a pandemic. As of 23 June 2021, 179,924,986 cases of Covid-19 and 3,897,835 deaths due to Covid-19 have been reported worldwide (worldometers.info/coronavirus/).

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On 25 January 2020, three tourists from China, who were also identified as close contacts with a Singaporean Covid-19 carrier, became the first-ever cases reported in Malaysia [The Borneo Post, 2020]. The first Malaysian tested positive for Covid-19 was a 41-year-old man, detected on 4 February 2020. On 17 March, it was reported that there were 2 deaths related to Covid-19. As of 23 June 2021, the Ministry of Health (MOH) has reported a total of 705,762 Covid-19 cases detected and 4,554 deaths throughout Malaysia, with the highest number of new cases per day recorded on 29 May 2021, which was 9,020 cases. The movement control order has been deployed, and at one point, Malaysia managed to flatten the curve. However, Covid-19 is back with more radical variants, and the number of cases in Malaysia is rising again.

The World Health Organization (WHO) has mentioned that Covid-19 can be transmitted through liquid particles exhaled from an infected person's nose or mouth. The size of the particles can be as small as aerosols or as large as liquid droplets from various activities such as talking, singing, sneezing, coughing, and even breathing. Within a 1-meter distance, a person can be infected if the liquid droplet that carries the virus comes into contact with a person's mouth, eye, or nose. Higher chances of Covid-19 transmission are observed in crowded indoor chambers and poorly ventilated areas, as it can remain in the air in the form of aerosols and liquid droplets for a duration of three hours and up to 72 hours on a surface [Doremalen, 2020]. Due to this condition, the donning of personal protective equipment (PPE) has become vital, resulting in supply shortages worldwide [Chaturvedi et al., 2020, Asyraf et al., 2020, Tino et al., 2020, Swennen et al., 2020, Wesemann et al., 2020].

In Malaysia, it is highly encouraged for everybody to wear double face protection [Bedi and Timbuong, 2021]. Due to the shortage of PPE, Prusa Research from the Republic of Czech initiated the printing of a three-dimensional (3D) face shield as another option for PPE production. This rapid prototyping technology, which can be used in-house, is gaining significant attention from the 3D printer community around the world, including Malaysia.

While there are studies and research regarding the development and the deployment of the face shield, the study regarding the user experience of the user remains scare. This paper describes the process of producing a 3D printed face shield and the testing conducted on the user. The test was carried out to assess the user's experience, mainly on essential workers working in Malaysia, while wearing the face shield during their work. While Mostaghimi in 2020 conducted user testing on healthcare workers (HCWs) with their version of the face shield to suit the needs of HCWs in a hospital environment, this paper focuses on the basic and much simpler design of the face shield, which is not only targeting HCWs but also for the benefit of other essential workers such as drivers, café workers, and government servants to carry out their duties in a non-controlled environment.

1.2 Face Shield

Face shield is one of PPE's components, which mainly consists of a clear plastic to cover the wearer's face and a form of bracket which holds the plastic to remain intact to the wearer's head [Wain, 2020]. There are several designs of face shield (refer to Figure 1); with the same objective, to cover the user's face for optimal protection from Covid-19 infection.

Fig. 1. Face shield design by https://3dverkstan.se/ [Asyraf et al, 2020]

1.3 Rapid Prototyping

Rapid prototyping (RP) is an automatic construction of 3D physical objects using solid freeform fabrication directly from a computer-aided design (CAD) [Murr, 2015]. Known as 3D printing, RP also refers to a range of new technologies which construct physical three-dimensional objects by assembling thin layers of material under a computer-controlled environment. Currently, 3D printing apparatus such as stereolithography (SLA) [Xu,2020], selective laser sintering (SLS) [Fina,2017] and digital light processing (DLP) [Zhang,2020] are widely used in medical and healthcare field [Mardis, 2018, Chepelev, 2017].

One of the 3D printing technologies, fused deposition modelling (FDM) uses polymers such as polylactic acid (PLA) as its feed material. PLA in filament form is fed into the printer through a heated nozzle and extruded while laying the melted PLA repeatedly on the bed plate producing the 3D object. Due to low initial and operating cost, together with effortless operating process, this printer become popular among 3D printing enthusiast [Asyraf et al, 2020, Liu et al, 2019, Park et al, 2016, Redwood et al, 2017]. For comparison, the printing speed of the FDM 3D printer is also ahead of other 3D printers of different technology [Seol et al, 2014, Gomes et al, 2020].

1.4 Production Process

A The production of face shield requires 4 main steps; acquire, conversion, printing, and assembly [Amin et al, 2020, Asyraf et al, 2020].

Acquire

In the first step, the face shield 3D file was acquired from a shared online portal, https://3dverkstan.se/ in Standard Triangle Language (.stl) format. However, after the initial printing and distribution, the feedback given was the head bracket is too tight, refer to Figure 2. Thus, the bracket's back opening is then expanded with additional 2.5cm using a Thinkercad software, as per Figure 3.

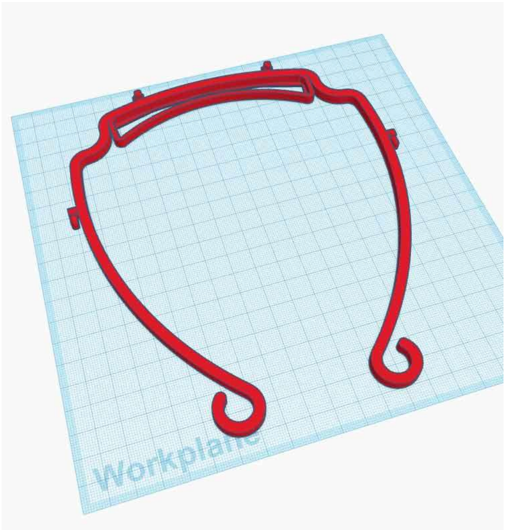

Fig. 2. Original file from https://3dverkstan.se/

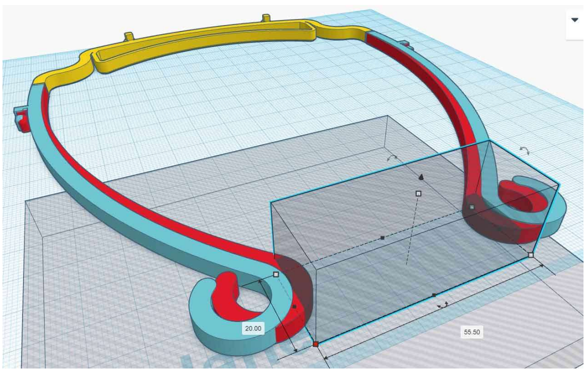

Fig. 3. Amendment on bracket's opening; blue part (wider opening) vs red part (original design

Conversion

The .stl file needs to be converted to G-code file prior to printing process. Amin in 2020 described that most of the FDM printer only uses G-code as standard format containing information such as diameter of the nozzle, the height of the layer and the infill percentage. In this step, Cura software is used for the software conversion. Cura software, which is developed by Ultimaker company, is used to define the printing setup such as layer height, infill, wall thickness and time gauging and material consumption.

Initial process set up:

Nozzle Size: 0.8mm
Layer Hight:0.3mm
Infill:10%
Speed: 40mm/s (manual double up after 2nd layer)

Production time of 15 minutes per face shield is achieved, which is much faster as compared to the default setting. This setting, however, produced a stiff bracket, that is unable to expand to accommodate bigger wearer's head circumference. Base on the feedback received, the setting is then changed to:

Nozzle Size: 0.4mm
Layer Hight:0.25mm
Infill:10%
Speed: 40mm/s

This setting results in a longer production time; 56 minutes per frame. This G-code file is later transferred to a secured digital (SD) card.

Printing

To print, 3 Ultimaker 2+ and 3 Ultimaker 2+ extended are used. Each printer produces 2 pieces simultaneously with the production time of 1 hour 52 minutes. Once the SD card is secured in the printer, the file is selected, and the printing begins. The PLA filament is fed via bowden tube into the heated nozzle (200 degree Celsius) and the motor moves the nozzle while laying the melted PLA on top on the heated bedplate (60 degree Celsius). There is no bracket or brim being set as the face shield required no support as per Figure 4.

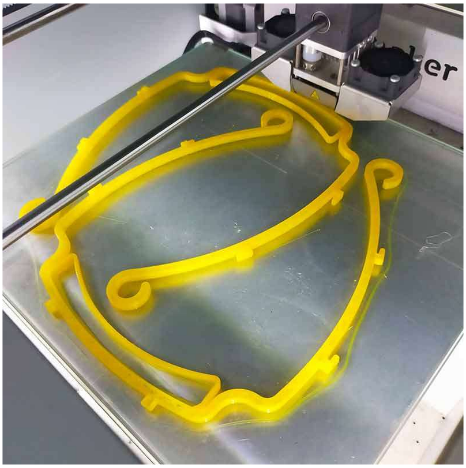

Fig. 4. Printing process

Assembly

Once the printing is done, the face shield is assembled by attaching the Polyvinyl Chloride (PVC) sheet to the 3D printed bracket. Four holes are punched on the PVC sheet using a paper puncher 8 centimeters apart. Once the PVC sheet is attached to the bracket, the face shield is ready-to-wear and ready for distribution.

2 Evaluation Method

The face shield wearing is a physical activity that involves the wearer or the user, the face shield itself and the environment where the user wears the face shield.

For this evaluation process, the think aloud method coined by Ericsson and Simon in 1984 is applied. The participant needs to think and express their feelings and experience while wearing the face shield and recall their thoughts on what they experience during completing their daily task while wearing the face shield. Eccles and Arsal in 2017 mentioned that using the think aloud method, the thought and the discussion will be much more stimulated.

The evaluation session involves 3 front-liners (a surgeon, a doctor and an e-hailing driver who transport personnel to quarantine station) and 4 essential workers (government servants, hardware store worker, and café worker). Each of the personnel is already aware and familiar with the usage of face shields. Each of them is given 1 face shield each. They are required to wear a face shield during their working hours for 5 days. On the last day, an in-person interview is conducted based on the respondent's location and availability. Verbal answers, comments, and response from the in-person interview are gathered and user's experience issues are identified, processed, and coded.

3 Result and discussion

Based on the study conducted, the respondents had a positive response to wearing the 3D printed face shield for the entire 5 days of their working hours. The majority of the respondents found the face shield to be very good, with only one respondent considering it to be good. A total of 130 verbal comments were collected during the survey session, and these comments were categorized into various user experience issues and other comments.

The study identified five categories based on the analysis of the user comments: accessibility, feasibility, visibility, comfortability, and aesthetic design. Accessibility refers to the ease of accessing the face shield and the concept of wearing it. Feasibility focuses on the actual wearing of the face shield in the respective work environment. Visibility concerns the user's vision while wearing the face shield. Comfortability is centered around the wearer's comfort level, and aesthetic design refers to the users' perception of the face shield's appearance.

Key findings from the study include:

- All users preferred the later version of the face shield.
- All users found the face shield to be easy to use.
- All users found the visibility during work to be good, with only one user experiencing minor distortion for the first few minutes.
- Six users felt very comfortable wearing the face shield during work, while one user felt a slight discomfort.
- All users found the face shield to be easy to clean and straightforward.
- All users expressed confidence in reusing the face shield after cleaning.
- All users preferred the setup of the 3D printed face shield compared to other options such as spectacles and span setups.
- Among the users who wore spectacles, only one user reported minor discomfort.
- All spectacle users found it easy to wear and remove the face shield without any hassle.

Overall, the study indicates a positive user experience with the 3D printed face shield, with users finding it easy to use, comfortable, and providing good visibility during work. The findings also highlight the importance of factors such as accessibility, feasibility, comfortability, and aesthetic design in enhancing the user experience of face shields.

4 Conclusion

During the Covid-19 pandemic, there has been a global shortage of personal protective equipment (PPE), including face shields. This shortage has led to the exploration of alternative options, such as 3D printed face shields. Prusa Research from the Republic of Czech initiated the printing of 3D face shields, which gained attention from the 3D printer community in Malaysia.

To assess the user experience of wearing these 3D printed face shields, a study was conducted among essential workers in Malaysia. The study aimed to identify the user experience components and provide recommendations to enhance the usability of the face shields.The study employed the think-aloud method, where participants were asked to wear the face shields for a period of five days. During this time, participants were encouraged to provide feedback and thoughts on their experience with the face shields. An open-ended questionnaire session was conducted to gather qualitative data.

Based on the feedback from the participants, several user experience components were identified. These components include accessibility, feasibility, visibility, comfortability, and aesthetic design.

Accessibility refers to the availability and awareness of various sources to acquire the face shields. Participants highlighted the importance of easy access to face shields, especially during a shortage.

Feasibility focuses on the ease of wearing and removing the face shields. Participants mentioned the need for a smooth process, regardless of whether they wear spectacles or other headgear.

Visibility is crucial to ensure that the face shield does not compromise the user's vision. Participants emphasized the need for a proper PVC sheet that does not distort or tint their vision.

Comfortability relates to the sizing and fit of the face shields. Participants noted that the sizing of the brackets should accommodate different head sizes, including those wearing hijabs or other headgear.

Aesthetic design plays a role in user confidence and satisfaction. Participants expressed a preference for minimalist designs that maintain the effectiveness of the face shields while also being visually appealing.

Overall, the study found that participants had a positive response to wearing the 3D printed face shields. They found them easy to use, providing good visibility, and comfortable. The study also highlighted the importance of considering factors such as accessibility, feasibility, visibility, comfortability, and aesthetic design in enhancing the user experience of face shields.

The findings of this study contribute to the understanding of user experiences with 3D printed face shields and provide recommendations for improving their usability. The study suggests that wearing face shields does not hinder healthcare workers and essential workers from carrying out their duties effectively, while also providing additional protection from harmful water droplets and aerosol particles.

It is worth noting that one participant even wore a 3D printed face shield during a surgery operation, demonstrating the versatility and confidence in the effectiveness of these face shields in various working environments.

In conclusion, the study emphasizes the importance of user-centered design in developing face shields. The recommendations provided in the study can guide future developments in 3D printed face shields and encourage further research on the usage of rapid prototyping in the post-Covid-19 era.

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