Face Shield 3D Printing User Experience Using Think Aloud Method During Pandemic in Malaysia

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Abstract. Acute respiratory disease later known as Covid-19 is pandemic origin from Wuhan, China. Detecting in 2019, this disease spread rapidly to entire world within few months. The ability to infect to the victim with aerosol spread has force to the medical personnel to wear a personal protective equipment (PPE) all the time when dealing with patient resulting shortage all over the world. To overcome with the shortage, a movement by three-dimensional (3D) printer user has start producing and distributing the face shield (component of PPE) to the medical personnel. A fused deposition modelling (FDM) 3D printer is chosen by many due to easy to use, fast production and low-cost material. While lots of study deals with the process and the production of 3d printed face shield, there is lack of study about the user experience (UX) of the printer's operator itself. Using a think aloud method to gather the information, this study intends to reveal the user experience of 3D printing of face shield by addressing the scope of the 3D printing process and the required engagement to accomplish the whole production cycle. Ten volunteers from different background and exposer to the 3d printing technology will be chose to participate in this study. Each verbal comment from the participant will be recorded, decoded, and mapped to the design and usability principle and this study expecting the UX issue and concern can be highlight and being presented.

Keywords: 3d printing · face shield · user experience · think a loud method

1 Introduction

The Covid-19 is a pandemic. Announced by the World Health Organization (WHO) on 11 March 2020, this Corona Disease 2019 was traced back to Hunan South China Seafood Market, Wuhan City province on 12 December 2019 (Guo, Cao, Hong et al. 2020). This acute respiratory disease then has spread throughout China and breach to rest of the world by the end of 2019. Coded as SARS-CoV-2 is a β-coronavirus which is enveloped non-segmented positive-sense Ribonucleic acid (RNA) virus (subgenus sarbecovirus, Orthocoronavirinae subfamily) (Zhu et al. 2020). It was confirmed that this virus originated from bats but how it was transmitted to humans is still unknown

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Fig. 1. Face shield design by https://3dverkstan.se/ (Mhd Pauzi et al., 2021)

(Li et al. 2022). As of 20 July 2021, 192,190,693 cases were detected, and the death toll has reached 4,123,780.

In Malaysia, the first case of Covid-19 was detected on 25 January 2020. It was traced back from 3 Chinese nationals who were infected by Covid-19 carrier in Singapore (Elengoe, 2020: New Straits Times, 2020).

On 4 February, the 41-year-old man was the first Malaysian who was infected by Covid-19. He was coughing and developing a fever upon returning from Singapore (Bernama, 2020). As of April 2022, Malaysia already reached 4,363,024 cases and 35,380 deaths were reported.

Covid-19 is transmitted by asymptomatic infected individuals and symptomatic individuals via oral fluid droplets, mainly airborne via coughing or sneezing. (Singhal, 2020; Adhikari, 2020; Yang, 2020). Within 1-m distance, a person can be infected if the mouth, eye, or nose come into contact directly with the liquid droplet that carries the virus (World Health Organization, 2020). Covid-19 also can be transmitted through crowded indoor chambers, poor ventilated areas and even on a surface since it can remain in air in a form of aerosol and liquid droplet; three hours on air and up to 72 h on surface (Doremalen 2020).

With the shortage of PPE worldwide, a rapid prototyping (RP) company, Prusa Research of Czech Republic together with the Oral and Maxillofacial team at the General Hospital of Cuiabá has initiate the production of face shield using a three-dimensional (3D) printing as an alternative (Gomes, 2020). This paper proposes to reveal the user experience of 3D printing of face shield by addressing the scope of the 3D printing process and the required engagement to accomplish the whole production cycle.

1.1 Face Shield

While A Face shield is one of PPE's components which mainly consist of a clear plastic to cover the wearer face and a form of bracket which hold the plastic to remain intact to the wearer's head (Wain, 2020). This face shields are designed in many forms and being designed to cover the full face for optimal protection (Fig. 1).

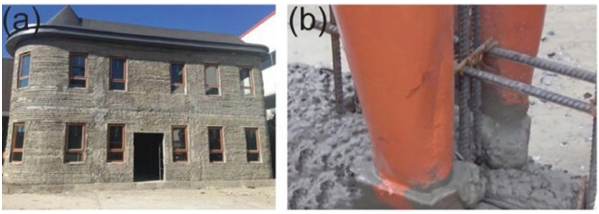

Fig. 2. (A) The two-story villa 3D printed by Huashang Tengda company; and (B) the novel nozzle of the giant 3D printer (Sanjayan, 2019)

2 3D Printing

3D printing of rapid prototyping (RP) is an automatic construction of 3d physical objects using solid freeform fabrication directly from a computer-aided design (CAD) (Murr, 2015). First developed by Hideo Kodama, 3D printing at that time was using single laser beam to and photo sensitive resin in 1980 (Su, 2018). RP also refers to a range of new technologies which construct physical three-dimensional objects by assembling thin layers of material under computer control such as material extrusion, vat polymerization, powder bed fusion, material jetting, and binder jetting (Redwood et al, 2017). Currently this technology is so diverse its being used in many industries from printing a food (Pitayachaval, 2018) to printing a house (Sanjayan, 2019) (Fig. 2).

Material extrusion uses solid thermoplastic; polylactic acid (PLA), acrylonitrile butadiene styrene (ABS) and thermoplastic polyurethane (TPU) material that being heated and melted by heated nozzle. This melted thermoplastic is being laid on the platform base on designated path which later is cools down and harden becoming a solid object. With low-cost material and good surface finish, this technology is suitable for household parts and small jigs and fixtures. However, this material is brittle and a not suitable for mechanical parts (Siemiński, 2021; Redwood, 2017).

Vat polymerization uses a light source to cure a photopolymer in a vat (Redwood, 2017). There are two technologies fall in this category which are stereolithography (SLA) and digital light processing (DLP). Producing a very high accuracy and fine finish, this technology has been using in dental and jewellery industry (Son et al., 2021)

Powder bed fusion either using polymer or metal powder is a technology that thermal energy to melt and fused the powder to become an object. Known as selective laser sintering (SLS) is being use for mechanical parts production due to its material strength (Li et al., 2022).

Material jetting (MJ) using light to harden the photopolymer or wax droplet. Since it can selectively deposit the material, it allows multiple material to be printed in one object resulting multicolour product that suitable medical models (Redwood, 2017). However, the cost is way higher that DLP and SLA.

Contrary with SLS, binder jetting (BJ) is using liquid binder to bind the powder. The printer head moves and deposit the binder droplet on the powder and binds the particle together to form an object (Sivarupan et al., 2021). This technology is suitable for sand casting as it is low cost and able to produce a large object.

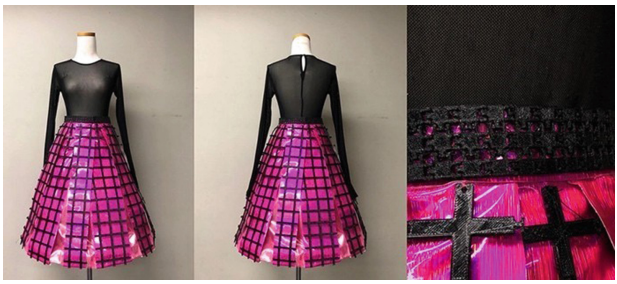

Fig. 3. 3D printed dress (Kim, 2019)

2.1 Fused Deposition Modelling

One of the famous technologies (Robert, 2020) is the fused deposition modelling (FDM) which using a polymer such as polylactic acid (PLA) as material. This printer will feed the PLA in a form of filament through the heated nozzle and move around while laying the melted PLA repeatedly resulting the 3d object. Due to the cheap cost to own and operate, together easy process to operate, this printer become popular among 3d printing enthusiast (Mhd Pauzi et al., 2021, Liu et al., 2019, Park et al., 2016, Redwood et al., 2017). Compared to the other technology, this fdm 3d printer also able to print faster (Seol et al., 2014, Gomes et al., 2020). Due to the versatility, low cost and easy to learn, this technology is being use in various industry like automotive (Romero, 2021), fashion (Kim, 2019), medical (Cheng, 2020), entertainment (HrabovskÝ, 2020) and even aerospace (Bilkar, 2021) (Fig. 3).

2.2 3D Printing Process

As being suggested by Amin in 2020 and Asyraf in 2020, the face shield printing process required 4 step which are acquire, digital processing, printing, and post-processing.

Acquiring the 3D data is the first step of 3D printing, it can be design and create by the user or being acquired from the third party such as shared portal or online database. This 3D data can be created from a 3D software such as Catia, Rhino, 3dsMax, Blender or TikerCad. It however needs to be saved as standard triangle language (STL) .stl file (Fig. 4).

Moving on to second step, this STL file need to process by a slicer software such as Ultimaker CURA. Several settings need to be done in this software to make sure the face shield can be printed in optimal time and quality. The nozzle size, printing height, wall thickness and density need to be set and finalize. This data later needs to be covert in Gcode file and ready to be print.

The third step is the actual printing. The Gcode is being transferred from computer to the 3D printer using secured digital (SD) card. At this point, the printer build plate need to properly level as to make sure the polylactic acids (PLA) layering process later will be disturbed. The build plate also needs to clean, and the plate surface is slightly rough. The hair spray or a glue stick will help to ensure that PLA will stick to the build plate until the printing process is finish. When the printing starts, the PLA filament will be

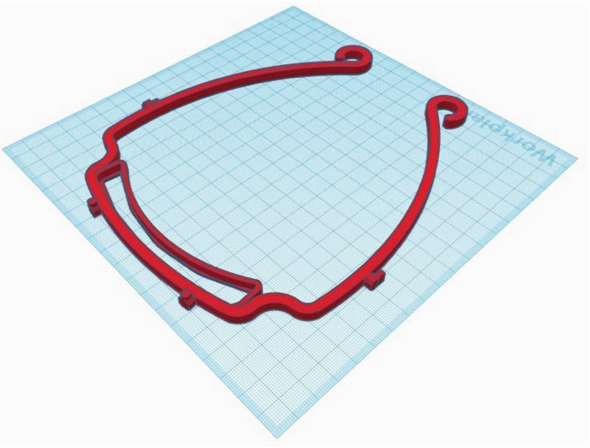

Fig. 4. Face shield in stl file, view in TinkerCAD software (Mhd Pauzi et al., 2021)

Fig. 5. Plyer, art clippers and paper puncher. (Mhd Pauzi et al., 2021)

feed through the Bowden tube to the well heated nozzle. This heated nozzle will move in X and Y axis while melted PLA is laid on the build plate that moves in Z axis until the object is formed and ready t be taken out.

The last step for the face shield printing process is post-processing. At this step, the printed face shield has been taken out from the printer and cleaned from the debris and the leftover PLA. A piece of transparent PVC sheet will be attached to the face shield via 4 holes. All the pointy parts of the PVC sheet will be cut into rounded corner to avoid injuries to the wearer. At this point, the production of the 3d printed face shield is consider done (Figs. 5 and 6).

Fig. 6. Stack of face shield and the process of removing the support structure. (Mhd Pauzi et al., 2021)

3 Evaluation Method

3.1 Procedure

The 3d printing process revolve around digital and physical activities which involves the operator (user of computer, printer, and assembler), the computer to process the 3d file, the printer itself, and component to assemble the face shield. The printing experience (UX) revolve around printing process and the operator's direct and indirect interaction with the printing device. To collect a data, a qualitative method using think aloud method (Khong 2019, Birns et al., 2002 and Petrie et al., 2010) involving the Faculty of Creative Multimedia employees and students. This method will require the participant to verbalize their though while performing a task (Fan, 2020) which is widely used in usability testing in sports (Whitehead, 2021), mobile app (Nasruddin, 2018), culture heritage (Khong, 2019), mathematics (Durksen, 2021) and UX course and syllabus (Fan, 2020; Carter-Roberts, 2021). Think aloud method is chose due to the researcher will be able to capture the participant thought in real time while they are going through the process (Alhadreti and Mayhew, 2018). While going through the face shield process, we hope that the user will be familiar with the process and may providing input and raise an issue during the questionnaire session right after the session.

3.2 Participant and Apparatus

This study will involve ten (10) users (5 men, 5 women with average age of 35), all are right-handed and member of local university who actively involved in community services. All of them must be already heard about the 3D printer, three of them will be a regular user, three novice user who been just learned to use the printers and four fresh user who will be introduce to the printer during this study. To participate into this study, all participants need to agree to not disclose their experiences, no picture taken during the process and adhere strict anonymity. To adhere the social distancing standard operation procedure (SOP) due to Covid-19 situation, only 4 personnel consist of one operator, one observer /interviewer and two participants will be allowed to be in the lab in one session. Each of the personnel will be place a minimum two metres from each other. Everybody is required to wear a mask and speak loud and clear during the session. This will be resulting a five session together.

The printing process will be conducted using Ultimaker 2+ printer, a FDM 3D printer together with laptop running on Intel i5 CPU, 8 GB Ram with on board Intel Graphic card. This study will be held in Prototyping Lab in the Faculty of Creative Multimedia building. The printer, computer and all the equipment to produce the face shield will be place on the working table in the lab. Participant will be allowed to walk around the setup throughout the whole production/printing process while maintaining the social distancing.

During the face shield production process which covering the 4 stages (acquire, slicing, printing, and assembly), the think aloud method will be used to gather spontaneous comment verbally and physically. Post- questionnaire also will be given to obtain the information and identifying the 3d printing UX issues.

4 Expexted Result

This study objective is to reveal the user experience of 3D printing of face shield by addressing the scope of the 3D printing process and the required engagement to accomplish the whole production cycle. From the whole session, this study expected to obtain a verbal comment that can be categorized into UX issue and other comments. This input later will be analysed and several UX issue being identify that can be mapped to design and usability principle. Even though there are no formal classification, Khong in 2019 have suggested that eight (8) categories to highlight the key of UX in this study. The eight categories are accessibility, inspection, environment, physical setup, control, visualization, editing, and archiving. However, based on the nature of 3D printing process, the categories that suite for this study will be, accessibility, digital processing, physical setup, environment, post processing and archiving.

Accessibility is about approaching and acquiring the data weather the data is being design and create or being acquired from the third party.

Accessibility also related to gain the access to the facilities and the materials.

Digital processing is related to the digital file that being acquired and need to slice using slicer software base on the production requirement and the needs of end user (face shield wearer).

Environment deals with the actual location where the production or the printing taking place; the ambient, the temperature, the humidity and soon.

Physical setup is all about preparation of the printing equipment, bed levelling, material preparation and care, and the consideration of scaffolding or closed cover for the printers.

Post processing relates to the printing process ends, taking out the product from the printer, cleaning up the bracket and assembling the face shield.

Archiving which deals with saving and archiving the data in physical and digital form.

Finally, this study expects that all the participants will be having a positive impression on the entire process of production of the face shield using 3D printing technology.

5 Conclusion

While world is moving to endemic phase, the COVID-19 still pose a threat to mankind. There is a lot more that we need to learn from this pandemic such as how to live after the endemic and what kind of physical protection that we can use to hinder from getting infected by this disease. One of the efforts is utilising the 3D printing technology to produce face shield or any other medical equipment. 3D printing is a hands-on, task oriented that require planning and resource management. To successfully print the face shield means accomplishing all step of the printing process. This study hopes to identify the UX elements throughout the printing process based on the think-aloud protocol and a questionnaire during the session.

Even it comes with challenges, this study is believed to provide an input to enhance and further up the UX and usability of 3D printing in the era of Covid-19 and Industry 4.0.

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