3D Printing PPE: A Three-Minute Face Shield Solution

Elizabeth Bishop
Postgraduate Researcher, University of Warwick, UK
About me

Elizabeth Bishop

• 2012 – 2017 MEng Mechanical Engineering
• 2016 – 2017 UAV Group Project
• 2017 – 2021 PhD in Large-Scale Additive Manufacturing (3D Printing)
• Maker in Residence at Warwick Engineering Build Space

@LizBish94
@WEDesignMake
Elizabeth Bishop
You may remember us from…
Learning Objectives

OBJECTIVE 1
Learn about the global maker's response to the COVID-19 crisis

OBJECTIVE 2
Learn how Warwick University responded and helped using 3D printing

OBJECTIVE 3
Learn how to print a PPE face shield in under three minutes

OBJECTIVE 4
Learn about large-scale additive manufacturing
Introduction
Coronavirus: Nottinghamshire woman, 75, ‘first positive test within UK’

25 August

Coronavirus pandemic:

New reported cases by day across the world

400,000 cases

300,000

200,000

100,000

0

Feb.
March
April
May
June
July
Aug.
Sept.
Oct.

New cases

7-day average

Note: The seven-day average is the average of a day and the previous six days of data.

New reported deaths by day across the world

5,000 deaths

0

Feb.
March
April
May
June
July
Aug.
Sept.
Oct.

New deaths

7-day average

Note: Scale for deaths chart is adjusted from cases chart to display trend.
Coronavirus: UK failed to stockpile crucial PPE

What is the situation with personal protective equipment in the UK?

1. PPE—or the lack of it—has been one of the key issues making headlines since coronavirus reached the UK
2. Coronavirus latest updates
3. See all our coronavirus coverage

Coronavirus: Has the NHS got enough PPE?

By Michelle Roberts
Health editor, BBC news online

Since the coronavirus outbreak in the UK was first identified, the issue of personal protective equipment, or PPE, has been a major concern for the NHS. As the pandemic continues, the demand for PPE has increased significantly, putting a strain on supply chains and testing the ability of healthcare systems to meet the needs of frontliners.

The shortage of PPE has led to concerns about the safety of staff and patients. The shortage has been particularly acute in hospitals and care homes, where staff are exposed to high levels of infection. The government has been criticized for not taking action early enough to ensure a sufficient stockpile of PPE was available.

In response, the government has unveiled plans to increase domestic production of PPE and to source supplies from overseas. The government has also announced measures to improve the way PPE is distributed, with a focus on ensuring that it reaches those who need it most.

As the pandemic continues, the issue of PPE will remain a critical one for the NHS and other healthcare providers. The government will need to continue to work to ensure that sufficient supplies are available to meet the needs of frontliners.

Related Topics
Coronavirus Q&A, Coronavirus, PPE, NHS, PPE supplies
What is PPE?
PPE protects the user against health or safety risks at work. It can include items such as safety helmets, gloves, eye protection, high-visibility clothing, safety footwear and safety harnesses. It also includes respiratory protective equipment, such as face masks.
Face Shields

A – Headband
B – Visor/Lens
C – Strap
D – Optional foam insert
E – Optional bottom reinforcement piece
3D Printing Community Response
Biggest Responders

Prusa Research
Printed and donated almost 200,000 shields

N3DPS
National 3D Printing Society, UK
Established UK distribution network for individual’s 3D printing PPE

3DVERKSTAN
Swedish distribution network for individual’s 3D printing PPE

Photocentric
Supplying NHS with 7.6 million face shields
What did we do?
What is Large-Scale Additive Manufacturing?
The process of joining materials to make parts from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing and formative manufacturing methodologies.

ASTM 52900
Large-Scale Additive Manufacturing

**DESKTOP SCALE**
*Ultimaker 3 Extended*

**LARGE-FORMAT**
*3DP WorkBench + E3D Extruder*

**LARGE-SCALE**
*3DP WorkBench + HFE (High Flow Extruder) 300*

**VERY LARGE-SCALE**
*Thermwood LSAM 1020*
## Advantages and Disadvantages

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>High flow rate</td>
<td>Extrusion control more difficult</td>
</tr>
<tr>
<td>Faster printing</td>
<td>- More stringing</td>
</tr>
<tr>
<td>Large-build volumes</td>
<td>- Artefacts in part</td>
</tr>
<tr>
<td>Stronger parts</td>
<td>Faster printing means more waste if it goes wrong</td>
</tr>
</tbody>
</table>
Designing in Fusion 360

Parameter Driven
2.5 mm nozzle

First Test Print

Printed in under 10 minutes
Time saving of at least 1 hour compared to other designs
What did we do? Part 2
Initial Design Iterations

VERSION 1
Attachment points too small
No where for strap to attach

VERSION 2
Added hooked outer attachment points for visor
Strap attachment designed

VERSION 3
Redesigned for true vase mode
Parallel Printing
6th April

- Established successful print workflow
- Designed bottom reinforcement piece for large-scale
- Printing top ad bottom headband using 3DPs
- Production line set up
- Started distribution to the community free of charge
- Working flat out
- Using A4 report cover sheets with a 4-hole hole punch to create the holes
- Design with BSI for testing
Tensile Testing
Elastic

Slow to make
Hand skills
Using a sewing machine

3D Printed Strap

Print 64 in 1 hour
Formed hot off the bed into curve
Automated process
BSI Testing

- Our A4 sheet just wasn’t big enough
- Needed to modify the headband to change the location of the visor
  Or
- Come up with a new supplier/solution for the visor
Version 4

COMPLETE RE-DESIGN

NEW FACE SHIELD KIT
Design Changes

- Narrower visor / more wrap
- Bottom reinforcement piece removed
- Longer visor
- 5 attachment points instead of 4
- Reduction in printing material
- Faster to print
BSI Testing

- Our A4 sheet just wasn’t big enough
- Needed to modify the headband to change the location of the visor
  
  Or

- Come up with a new supplier/solution for the visor
Conclusions
Summary

OBJECTIVE 1
Learn about the global maker's response to the COVID-19 crisis

OBJECTIVE 2
Learn how Warwick University responded and helped using 3D printing

OBJECTIVE 3
Learn how to print a PPE face shield in under three minutes

OBJECTIVE 4
Learn about large-scale additive manufacturing
Want More?

REACH OUT ON MY SPEAKER / CLASS PAGE

READ MY PUBLISHED JOURNAL PAPER


JOIN ONE OF MY OTHER CLASSES

Stressing Out: Simulation Workspace in Fusion 360

Fusion 360 and 3D Printing: Tips and Tricks for a Successful Workflow