TEACHING BEYOND THETIMETABLE

How PhD Research Enabled Undergraduate Teaching – A Pandemic Outlook

Elizabeth G. Bishop

PhD Researcher & Senior Graduate Teaching Associate, School of Engineering
Maker in Residence, Engineering Build Space, School of Engineering

Correspondence: E.G.Bishop@warwick.ac.uk
Twitter: @lizbish94

Elizabeth is a Postgraduate Researcher (PhD Student) and Teaching Fellow at the University of Warwick researching Large-Scale Additive Manufacturing (or 3D Printing). Elizabeth has been interested in 3D printing for several years now, investigating research topics across a wide range of applications for Fused Filament Fabrication, from mould tooling, to direct part manufacture in the aerospace and automotive industries. More recently her focus has been on Large-Scale Additive Manufacturing, the difficulties surrounding this emerging technology, and its exciting applications. Elizabeth is also a Maker in Residence in the Engineering Build Space at Warwick University where she is exploring making, CAD, and CAM alongside 3D printing.

Abstract

This article explores the use of PhD research at the forefront of technology to manufacture lifesaving PPE items such as face shields and how this University based research enabled face-to-face teaching to resume in the School of Engineering.

Keywords: 3D Printing, PPE, Face Shield, Engineering, Face-to-Face Teaching, Women in STEM

Introduction

In late 2019, an outbreak of infections from a novel coronavirus (now named SARS-Cov-2) was reported in China (**Riou and Althaus 2020**). The spread of this coronavirus disease 2019 (also more commonly known as COVID-19) reached the necessary level of spreading to be classified as a global pandemic according to the World Health Organisation (WHO) (**WHO 2020c**). The virus reached the UK in March 2020, and many universities were thrown into disarray as campuses were shut down, exams were cancelled, and students were forced to finish the academic year online. In It is clear in retrospect that in September 2020 the pandemic was far over. Nonetheless, for the new autumn term, the University of Warwick had in an attempt to reduce student deferral rates (**Economics 2020**) promised all students 'an element of face-to-face teaching'.

A lack of physical, face-to-face teaching would be particularly problematic for a subject like Engineering. Practical labs are a signature pedagogy in higher education engineering courses (**Lucas and Hanson 2016; Goodhew 2010**) which necessitate face-to-face teaching. There are many skills which cannot be learned, except through in-person experience. There is simply no equivalent to physically experiencing, for example, soldering an electronics board or drilling a hole in a piece of wood. These learning experiences provide students with the necessary base skills to become chartered engineers, and are therefore required on accredited undergraduate courses by accrediting bodies such as the Institute of Mechanical Engineers (IMechE) and the Institute of Engineering and Technology (IET). As the Engineering Council state that for degrees to be accredited students must demonstrate "… a practical understanding of how established techniques of research and enquiry are used to create and interpret knowledge in the discipline." (**Engineering Council 2020**). Without such accreditation and understanding students cannot become Chartered Engineers.

This article explores the author's contributions to and experiences of finding a solution for secure in-person engineering teaching. It represents a direct example of the potential impact of PGR research both in terms of shaping approaches to teaching and the wider community. The research process detailed in this article enabled the University of Warwick's School of Engineering to deliver a safe and effective blended learning course for its students with the necessary face-to-face teaching during the heavily disrupted academic year 2020-2021.

3D Printing PPE

The COVID-19 pandemic had a huge impact on the supply of Personal Protective Equipment (PPE). COVID-19 was being spread by aerosol and droplet infection, which occurs (as with influenza) occurs when droplets from an infected individual are generated during coughing, sneezing or even talking and pass through the air and land on the eyes, nose and mouth of another individual leading to infection (**Ather et al. 2020; WHO 2020a**). The general public were being asked to wear face coverings such as face masks and face shields to help reduce the spread of infection (**WHO 2020b**). On top of this extraordinary demand, the closing of shipping lanes and grounding of flights across the world led to a disruption in supply chains of essential PPE such as face masks, gowns, gloves, and eye protection. The shortage in countries like the UK was compounded by those countries who were manufacturing these items turning their priority to home use. The combination of more people wearing face masks beyond the normal expectations and the disrupted supply chains led to a world-wide shortage of PPE. This left the UK medical community in a desperate situation.

In response to this unprecedented demand for PPE, many companies, academic institutions, and individuals sought to use equipment such as 3D printers (generally FFF, Fused Filament Fabrication systems) to produce components for much needed PPE items such as face shields (**Larrañeta, Dominguez-Robles, and Lamprou 2020; Flanagan and Ballard 2020**). Additive Manufacturing, also known as 3D printing, is a process whereby parts or objects are made by laying down layers of plastic material to build up a 3D part from a digital model. Using these [methods?] and to address the PPE shortfall members of the international 3D printing community came together in vast, rapidly formed collaborative networks to share PPE designs. Many of the community-driven designs were produced on desktop-scale 3D printers, typically taking 1-2 hours to produce.

Taking inspiration from the existing designs, the author decided to use their PhD research in Large-Scale Additive Manufacture to produce a design specifically for the large-scale machines in the University of Warwick's Engineering Build Space. These machines, with larger nozzles and faster volumetric flow rates, are capable of printing components much faster, resulting in a face shield that could be manufactured in just 3 minutes. This design passed BSI testing, ensuring that it conformed to required standards to be used in medical settings, unlike several other designs already in circulation.

Initially, these were produced for front-line medical workers, before expanding to supplying the key workers in the community, such as teachers and shop workers. It was at this point that the University of Warwick asked for the face shields to be produced for university staff to use. The University of Warwick had noticed accessibility issues around mandatory mask wearing, for example, those who wear hearing aids struggling with the interference that face mask straps cause. Those who use lip reading as a main communication method also struggled when trying to communicate with others who were wearing face masks that obscured their mouths. It was feared that similar issues could arise in classroom setting once in-person teaching resumed. The face shields, consisting of a clear visor (**Figure 1**), by contrast, allow effective communication between the wearer and those around them, whist also preventing droplet transmission. Over the course of the COVID-19 pandemic, the author has manufactured, packaged, and distributed over 7000 face shield kits to front-line workers, the community, and staff and students at the University of Warwick.

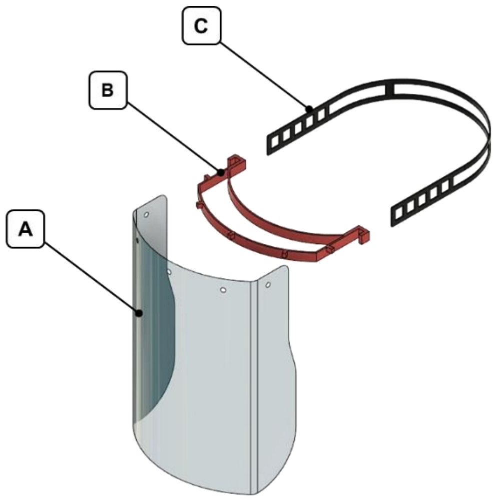

Fig. 1: *Typical components making up a face shield, a) visor, b) 3D printed headband and c) 3D printed strap.*

Pandemic-Proof Face-to-Face Teaching

In addition to producing viable and high-quality PPE, the author's work on the face shields, conducted in-person and on-site in the university's labs, proved that the labs could be used in a safe socially-distanced manner. Moreover, the face shield design itself would become a key piece of equipment in ensuring safe and effective teaching at the university.

The University of Warwick stipulated that from the start of the 2020-2021 academic year, any in-person teaching would need to be conducted at 2 metre plus wearing a face mask. These restrictions put huge strains on departments such as the School of Engineering who had neither the time nor capacity to conduct practical laboratory sessions for over 350 students (per year) in this way. A compromise was reached at the

University of Warwick, allowing for in-person teaching to be conducted at 1 metre plus (between 1 and 2 metres) if everyone present in the room wore a face mask *and* a face shield. Hence, the School of Engineering was able to increase the capacity that rooms were allowed and could restore some of the previously unthinkable practical sessions. The face shields also allowed for final year students to return to their practical group projects using advanced equipment only available in the Engineering Build Space (**Figure 2**).

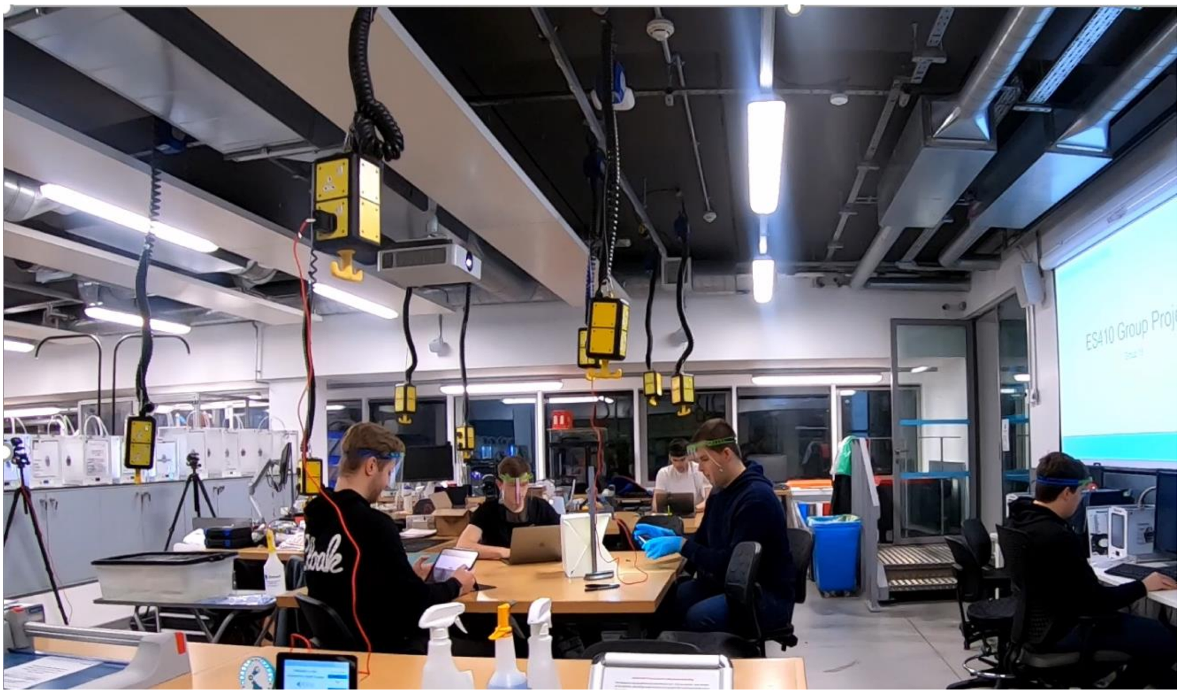

Fig.2: *Undergraduate students returning to practical work, wearing protective face shields made with 3D printed components.*

The Woman Behind the Mask – Some Concluding Thoughts

Overall, the work of the author, the woman behind the mask (**Figure 3**), has shown that PhD research can play a key part in the teaching curriculum. Their work on 3D printed face shields has not only aided the community in unprecedented times but has enabled the School of Engineering to deliver a safe and effective blended learning course for its students including the essential face-to-face teaching needed in Engineering degrees. The visible role of PhD research is at the heart of the author's teaching philosophy, showing what research at the forefront of technology can do in a teaching space such as the Engineering Build Space at the University of Warwick.

Fig.3: *The woman behind the mask.*

References

Ather, A., B. Patel, N. B. Ruparel, A. Diogenes, and K. M. Hargreaves. 2020. "Coronavirus Disease 19 (COVID-19): Implications for Clinical Dental Care." J Endod 46 (5): 584-595. https://doi.org/10.1016/j.joen.2020.03.008. https://www.ncbi.nlm.nih.gov/pubmed/32273156.

Economics, London. 2020. "Impact of the Covid-19 pandemic on university deferral rates and student switching."

Engineering Council. 2020. Accreditation of Higher Education Programme.

Flanagan, S. T., and D. H. Ballard. 2020. "3D Printed Face Shields: A Community Response to the COVID-19 Global Pandemic." Acad Radiol. https://doi.org/10.1016/j.acra.2020.04.020. https://www.ncbi.nlm.nih.gov/pubmed/32335004.

Goodhew, Peter J. 2010. Teaching Engineering, All you need to know about engineering education but were afraid to ask.

Larrañeta, Eneko, Juan Dominguez-Robles, and Dimitrios A. Lamprou. 2020. "Additive Manufacturing Can Assist in the Fight Against COVID-19 and Other Pandemics and Impact on the Global Supply Chain." 3D Printing and Additive Manufacturing. https://doi.org/10.1089/3dp.2020.0106.

Lucas, Bill, and Janet Hanson. 2016. "Thinking Like an Engineer: Using Engineering Habits of Mind and Signature Pedagogies to Redesign Engineering Education." International Journal of Engineering Pedagogy (iJEP) 6 (2). https://doi.org/10.3991/ijep.v6i2.5366.

Riou, J., and C. L. Althaus. 2020. "Pattern of early human-to-human transmission of Wuhan 2019 novel coronavirus (2019-nCoV), December 2019 to January 2020." Euro Surveill 25 (4). https://doi.org/10.2807/1560-7917.ES.2020.25.4.2000058. https://www.ncbi.nlm.nih.gov/pubmed/32019669.

World Health Organization. 2020a. "Modes of transmission of virus causing COVID-19: implications for IPC precaution recommendations." Intensive Care Med 46 (5): 854-887. https://doi.org/10.1007/s00134-020-06022-5. https://apps.who.int/iris/bitstream/handle/10665/331601/WHO-2019-nCoV-Sci_Brief-Transmission_modes-2020.1-eng.pdf?sequence=1&isAllowed=y.

---. 2020b. "Rational use of personal protective equipment for coronavirus disease 2019 (COVID-19)."

---. 2020c. "WHO Virtual Press Conference on COVID-19." https://www.who.int/docs/default-source/coronaviruse/transcripts/who-audio-emergencies-coronavirus-press-conference-22apr2020.pdf?sfvrsn=4f8821b6_2.

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