DEMO or DIE

Develop Engaging Massive Open Online Resources for Designers Innovative Education

DOD ARTICLE #1: Online Training for 3D Printing in Response to Covid-19

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DEMO OR DIE (DOD) is a European Commission-funded Erasmus+ programme that started in 2021 with a view of promoting Open Access to Online Training in 3D Printing. The vision is to enable professionals from non-manufacturing backgrounds as well as students from vocational education and higher education to learn about the potential opportunities and designing for Additive Manufacturing (AM), and to understand the use and operation of desktop 3D printers to more fully embrace digital technologies. AM, commonly known as 3D Printing, is the general term for technologies that successively join material(s) one layer at a time in a precise position to create physical objects specified by 3D model data (ISO/ASTM 52900). AM technologies can be classified into seven categories, which are Binder Jetting, Directed Energy Deposition, Material Extrusion, Material Jetting, Powder Bed Fusion, Sheet Lamination and Vat Photopolymerization. Among these, Material Extrusion (MEX) is the most commonly used due to its widespread availability, low-cost, being safe and easy to operate. MEX is also commonly known as Fused Deposition Modelling (FDM) which the name has been trademarked by the company Stratasys. All 3D Printing processes offer complex geometries to be fabricated more easily than traditional processes due to its layer-by-layer method of production that allows freeform shapes to be produced on demand.

Several studies have been published to discuss how 3D Printing could be used to support humanitarian needs, such as during critical situations like the Covid-19 pandemic. Patel and Gohil (2020) reported that the World Health Organization (WHO) had issued a list of Covid-19 critical items that faced a global shortage, grouping the products into three categories such as Personal Protective Equipment (PPE), Diagnostic Equipment and Critical Care Equipment. PPE products include wearable protective clothing, helmets, gloves, face shields, goggles, surgical masks, respirators or other miscellaneous equipment designed to protect the wearer from exposure to infection. Salmi et al (2020) suggested that the COVID-19 pandemic had increased pressure on manufacturers to consider making the designs of critical products more freely available, where at times spare parts may not be accessible due to disruption in production plants, logistics or supply chains. Their work also provided compelling statistical evidence that the most potential healthcare products such as face masks, nasal swabs, face shield holders and Venturi valves can be manufactured using 3D Printing with a single set of tools and with the widespread availability of equipment in the market. Vordos et al. (2020) undertook a further study to analyze which types of PPE can be produced and more importantly how 3D Printing users can be coordinated to achieve mass printing volumes. Similar to Salmi et al (2020), they found that valves, masks with filters, hands-free door handles, scuba-diving adaptors, mask adjusters and face shields could be 3D Printed and many of these were also available to be downloaded from the internet. They found a total of 109 different designs of face masks, 30 designs for respirators, and other designs for goggles, etc. More importantly, they noted that although these

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designs are freely available, a serious concern remains whether the designs have been approved for use such as by the American National Institutes of Health (NIH) or the United States Food and Drug Administration (FDA). In response, the FDA partnered with NIH, the Department of Veterans Affairs and America Makes to collect, test, and validate different designs of 3D printable medical equipment, and to provide safety guidance to the public (Manero et al., 2020). Of these, many designs that were approved were related to face shields due to the simplicity of their design and less stringent requirements from the FDA (Novak and Loy, 2020), since these shields were recommended by the Centers for Disease Control and Prevention (CDC) for eye protection and to also lower the extended use of N95 respirator during severe shortages (CDC, 2020).

Mueller et al. (2020) found that the use of MEX was the most convenient AM technology to produce PPE since it is relatively easy to quick to set up, low cost of printers and material, and the widespread use enabled makers within a community to work together. More importantly, they noted open-source software applications and platforms that allow for sharing of files, making it possible for persons with no access to sophisticated CAD or modelling software to print complex designs. Their study also noted differences in terms of quality of parts, variation of material quality from different suppliers, and high amount of waste being produced during the production of face shield headbands. Tarfaoui et al. (2020), Amin et al. (2020) and Celik et al. (2020) also presented case studies that examined the design and production of specific parts, comparing different digital design files of PPE that were created and freely shared online based on the printing time, filament used, estimated cost, functionality, disinfection rates and part geometry that showed that some of these designs were more efficient to print in terms of the time required and the amount of material that was used. Budinoff et al (2021) found that a few of the most pressing challenges include using a proper design process to ensure proper functionality, using the correct printing parameters, and ensuring the safety of operators. Therefore, assurance for 3D Printed PPE to be made readily available will not only be realized by means of access to 3D printers and having a network of users available to operate them safely. More importantly, training the proper and safe use of 3D printers, as well as having the right skills to design PPE products or to make modifications and adjustments is important to ensure compliance for use. Figure 1 shows face shields produced by the author (Giselle Hsiang Loh) as part of a community drive in the UK to manufacture PPE in response to the needs of local healthcare practitioners. The design of the face shields and production could be carried out easily if the individual has the correct training, know-how in using the software and the skills to operate a 3D printer.

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Figure 1: Face shields produced during Covid-19. Credits: Giselle Hsiang Loh

In response, DEMO OR DIE (DOD) will provide training in the form of easy-to-follow Competence Units (CUs) that will be delivered by the consortium technological centers and universities. The four CUs include an "Overview of 3D Material Extrusion (MEX)" by AITIIP Technology Centre based in Zaragoza in Spain, an "Introduction to Computer-Aided Design (CAD)" by Brunel University London in the UK, "Design for Material Extrusion (MEX)" by the Laboratory for Manufacturing Systems and Automation at the University of Patras in Greece, and "3D Printer Operation and Practical Applications" by FAN3D based in Portugal and the European Welding Federation in Brussels. The learning path is illustrated in **Error! Reference source not found.**2.

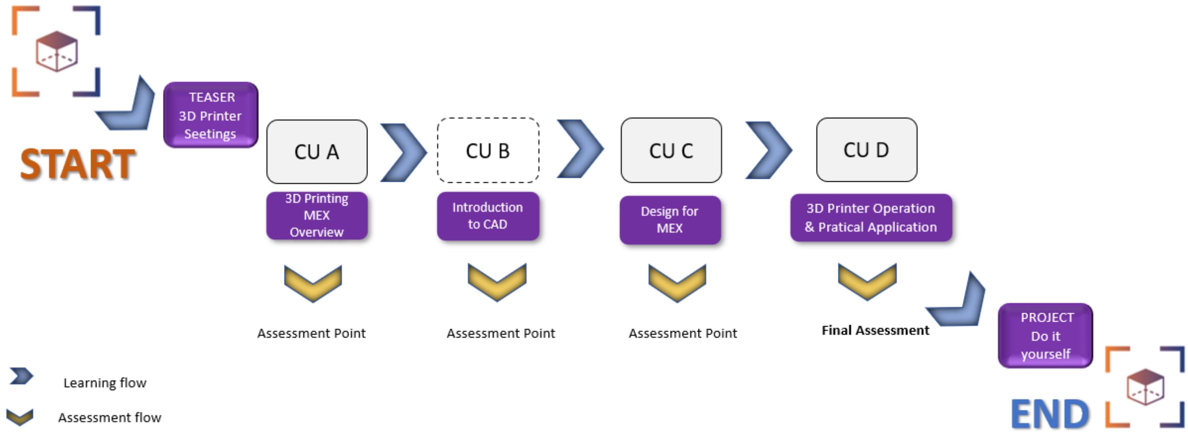

Figure 2: DEMO or DIE learning path

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The series of training will be conducted online with interactive quizzes and with summative assessments towards the end to ensure that the learning can be fully applied to make a real impact for society with these lifelong skills. If you are interested, please follow us on our website to register via: https://www.demoordieproject.eu.

References

1. Amin, D., N. Nguyen, S.M. Roser and S. Abramowicz (2020) 3D printing of face shields during COVID-19 pandemic: a technical note. J Oral Maxillofac Surg. 10.1016/j.joms.2020.04.040
2. Budinoff, H.D., Bushra, J. and Shafae, M. (2021) Community-Driven PPE Production Using Additive Manufacturing during the COVID-19 Pandemic: Survey and Lessons Learned. J. Manuf. Syst. https://doi.org/10.1016/j.jmsy.2021.07.010.
3. CDC (2020) Infection control: severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) https://www.cdc.gov/coronavirus/2019-ncov/hcp/infection-control-recommendations.html
4. Celik, H.K., O. Kose, M.E. Ulmeanu, A.E. Rennie, T.N. Abram and I. Akinci (2020) Design and additive manufacturing of medical face shield for healthcare workers battling coronavirus (COVID-19) Int J Bioprint, 6 (4). pp. 1-21, 10.18063/IJB.V6I4.286
5. ISO/ASTM (2017) ISO/ASTM 52900:2017 Additive manufacturing- General principles-Terminology, ISO/ ASTM. West Conshohocken, PA, USA
6. Manero, A., P. Smith, A. Koontz, M. Dombrowski, J. Sparkman, D. Courbin, et al. (2020) Leveraging 3D printing capacity in times of crisis: recommendations for COVID-19 distributed manufacturing for medical equipment rapid response. Int J Environ Res Public Health, 17 (13). pp. 1-17, 10.3390/ijerph17134634
7. Mueller, T., A. Elkaseer, A. Charles, J. Fauth, D. Rabsch, A. Scholz, et al. (2020) Eight weeks later-the unprecedented rise of 3D printing during the COVID-19 pandemic – a case study, lessons learned, and implications on the future of global decentralized manufacturing. Appl Sci, 10 (12) (2020), pp. 1-14, 10.3390/APP10124135
8. Novak, J.I and J. Loy (2020) A critical review of initial 3D printed products responding to COVID-19 health and supply chain challenges. Emerald Open Res, 2 (24). 10.35241/emeraldopenres.13697.1
9. Patel, P. and Gohil P. (2020) Role of additive manufacturing in medical application COVID-19 scenario: India case study J Manuf Syst, 10.1016/j.jmsy.2020.11.006
10. Salmi, M., Akmal, J.S., Pei, E., Wolff, J., Jaribion, A. and Khajavi, S.H. (2020) 3D Printing in COVID-19: Productivity Estimation of the Most Promising Open Source Solutions in Emergency Situations. Appl. Sci. 10, 4004. https://doi.org/10.3390/app10114004
11. Tarfaoui, M., M. Nachtane, I. Goda, Y. Qureshi and H. Benyahia (2020) Additive manufacturing in fighting against novel coronavirus COVID-19. Int J Adv Manuf Technol, 110 (11–12). pp. 2913-2927, 10.1007/s00170-020-06077-0
12. Vordos, N. D., Gkika, G. Maliaris, K. Tilkeridis, A. Antoniou, D. Bandekas, et al. (2020) How 3D printing and social media tackles the PPE shortage during Covid-19 pandemic. Saf Sci p. 130, 10.1016/j.ssci.2020.104870

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