AMJ Australasian Medical Journal [AMJ 2023;16(4):604-607]

Role of three-dimensional printing and virtual reality in medical applications: A medical student's reflection

William Tang[1], Shijie Wang[1], Zhonghua Sun[2*]

[1]Curtin Medical School, Curtin University, Perth Australia

[2] Discipline of Medical Radiation Science, Curtin Medical School, Curtin HIVE, Curtin University, Perth, Australia

EDITOR NOTE

Please cite this paper as: Tang W, Wang S and Sun Z. Role of three-dimensional printing and virtual reality in medical applications: A medical student's reflection. AMJ 2023;16(4):604-607

https://doi.org/10.21767/AMJ.2023.3947

Corresponding Author:

Zhonghua Sun
Discipline of Medical Radiation Science,
Curtin Medical School, Curtin University,
Perth, Australia
z.sun@curtin.edu.au

ABSTRACT

Dear Editor,

In this letter, I would like to share a reflection of my time learning about the role of three-dimensional (3D) printing and virtual reality (VR) technologies in medicine. I am a 3rd year medical student at Curtin University, and I was recently involved in an immersion program to learn about the research conducted by the researchers at Curtin Medical School.

The purpose of the program organised by the Curtin Medical School is for medical students to expose themselves to the different facets of healthcare, particularly the different community organisations that contribute to improving health care and equity outside the hospital. For this particular allocation, we had the opportunity to observe the research of 3D printing and VR in medical applications.

During our observation over a 2-week period, we were able to interact with researchers and research students discussing projects that utilised 3D printing and VR technologies in both educational and clinical value. A few of the applications we were able to witness included the use of 3D printing to tangibly visualise congenital heart defects, coronary artery stenosis and aortic aneurysms. Likewise, these cases were also able to be translated into a VR simulation, which we were given the opportunity to experience it at Curtin Hub for Immersive Visualisation and eResearch (HIVE). The research projects that we experienced included heart models with congenital heart disease and a cardiac tumour, and a liver model with multiple tumours in the hepatic parenchyma (Figure 1).

In addition to learning about the medically orientated projects, we also observed the implementation of these 3D printing and visualisation techniques in a variety of different other industries. Not only did we get to learn what these technologies are, such as the stereoscopic imaging in the panoramic system, at Curtin HIVE, we also had the opportunity to learn and discuss how each system is developed (Figure 2). Points of discussion included the image post-processing and segmentation process, and smoothening algorithms in producing 3D models from computed tomography (CT) images, different 3D printing techniques and types of materials available for printing, and program development for VR systems. Despite being exposed to these novel technologies in a very short period of time, we gained a greater appreciation of the potential use of these technologies in the healthcare sector, in both its educational value and clinical applications.

The use of 3D printing and VR in medicine has long been a popular point of discussion since the development of these technologies, and even more so with their increasing accessibility and outreach to people beyond the niche [1,2]. In recent years, with the availability of open source software tools and online tutorials, engaging and creating a 3D model, or experimenting with these 3D visualisation techniques no longer requires any in depth computer software knowledge, nor does it have to be expensive, with much of the technology being available and affordable for routine use[3]. The future of this technology can be seen with its ever increasing interest, researched by tertiary institutions and the commercialisation of technology, for educational purposes, and even in the management of patients for a variety of diseases.

While we saw many projects being undertaken during our immersion program, these applications of the technology only encompass part of all of the creative usages being employed just purely for medicine. A large amount of our time focused on the educational value of 3D printing and VR. Notably the creation of 3D printed congenital heart disease and aortic aneurysm models. Discussion of their advantages included providing intuitive visualisation for medical students, health professionals and patients compared to 2D visualisation on a computer screen (CT, or even a digital 3D model) [4,5]. In particular, its educational value in a clinical setting should be acknowledged, allowing case study and operative simulation training for future cases [3-5]. Similarly, we had the opportunity to experience similar models in virtual reality, as well as a liver model with tumours embedded. The virtual reality system, though not tactile like the 3D models, still provided an immersive experience to visualise 3D models, with the added advantages of being able to segment and dissect elements of the models if programmed, as well as expand or shrink the models. Additionally, the simulations available to us were easily controllable, the user interface using basic hand gestures or simple hand remote controls that were intuitive to pick up. The educational value of these simulations can be seen in the better 3D visualisation of anatomy and pathology than that is provided through textbooks or medical imaging, and is potentially more accessible to students or learners than accessing a cadaver lab for comparison. Likewise, its clinical usefulness could be seen in preoperative and procedural planning, simulation and training.

Being able to see not only the end product and operational system, but also the developmental process for the systems, I think was an invaluable experience during this immersion program. Appreciating the need for collaboration between clinical specialists in the field and those with expertise with technology is not only essential in optimising and producing the best results, but also understanding the limitations of the technology and where its implementation is more appropriate than other areas (Figure 3). From a clinical point of view, being able to see the potential and capabilities of the technology, and learn the available systems would provide a clearer idea as to how these technologies would be implemented into current and future medical applications. While the potential of 3D printing and VR seems limitless, it is important to acknowledge the financial, time and technical restraints when applying these technologies, whether it be medical education or in a clinical setting. With both of these, before the models are printed or incorporated into a virtual system, CT or magnetic resonance (MR) imaging datasets need to be converted into a 3D model, by undergoing several steps of image post-processing and segmentation. While current applications and systems have made the process more streamlined and approachable for beginners to computer-aided design (CAD) software, the process is still time intensive and requires manual input for desirable results[3].

With 3D printing, there are technical limitations to what can be printed, and the properties the model may possess, such as the rigidity or texture based on the material used. Additionally, understanding that each model produced can take several hours, if not days, to print depending on resolution and quality of the printer, and the high expenses associated with not only printing each model, but also investing in the technology in tertiary healthcare shouldn't be disregarded. These considerations are important when designing the potential implementation of 3D printing in a clinical setting. For example how the time limitation would make pre-operative models for training and preparation difficult for emergency cases, such as a symptomatic aortic aneurysm. Instead, its usage would be more suitable in stable patients for operative planning and simulations, case study and simulative learning for professional development, or for the development of prosthesis or implants that are tailored to each patient – situations that have allowance for time. While our immersion mainly focused on cardiovascular applications, and resin based printing, we were also shown with metal 3D printing and discussed its applications, in particular, its use in the creation of tailored prosthetics such as for joint replacement or neurocranial plates[6,7]. Further discussion and experimentation with bio printing is also an area of research of interest, particularly with the potential to 3D printed patient-specific organs in order to avoid transplant rejection and tissue matching. Even the possibility of using tissue mimicking materials for grafts, prosthesis and surgical training is another area of consideration[8,9]. Solely with 3D printing alone, recognising the many capabilities of the technology can provide plenty of creativity for healthcare specialists to solve problems within their field, however to make these ideas a reality, careful consideration of the limitations, whether financial, technical or time related, are necessary. Communication and collaboration with technical experts, and learning about the processes involved are important factors in order to maximise the potential of 3D printing.

Likewise with the applications of VR, one's imagination is truly the limit in its development, yet recognition of the barriers in its usage and what technical constraints are existing is required for it to be used appropriately. As mentioned before, the process of creating 3D models, particularly anatomical structures from CT and MR images, can be a time consuming and labour intensive process. The time and labour associated with the preparation and the development of these programs would increase further if one desired to create a program with fully original and custom 3D models. Beyond these constraints, technical limitations in resolution, particular controller actions or processing power are other important considerations, especially with the range of headsets or visualisation mediums available. For the individual or organisation that considers implementing VR technology or any other visualisation model into their field, it is necessary to layout the objectives and purpose this technology would be used for, and the budget available. With our time at Curtin HIVE, we were able to observe some of the latest innovative and advanced visualisation technologies, which allowed a significant degree of immersion in the simulations, allowing finger-tracking and controller interaction, as well as the opportunity to open the experience to outside onlookers. Additionally, we had the opportunity to interact with the panoramic stereoscopic imaging visualisation, which allowed multiple individuals to participate in the 3D immersion without the need for each person to have a headset. Comparatively with commercial VR industries, such as Vantari VR, using Oculus Quest 2 held a similar degree of immersion, focusing on procedural training in a clinical setting. In the healthcare setting, while the educational and training value of virtual reality is apparent, its usage also extends into patient management, such as in therapeutic relaxation or rehabilitation of medical conditions in a gamified and possibly more engaging manner[10-12]. With all these possibilities, the major barrier for accessibility would be the associated financial costs. For VR, headsets could be as simple and affordable as goggles to encase your mobile device and view a present immersive video, or as advance as multi-sensory immersion with haptic gloves. From a clinical perspective, these constraints highlight the need for ingenuity and focus on what our goals, whether it is for educational use or patient management. A mobile device headset could possibly be adequate for a surgical learning, observing the surgery for the surgeon's perspective or gain an appreciation of the daily activities or other health professionals. Furthermore, the implementation of more advance controls would allow a more interactive experience with procedural or case training, or perioperative planning.

The research and development of 3D printing and VR technologies is a growing and exciting field. It can provide a range of solutions to the education of medical students and other health professionals, to the management of patients, both in planning and directly in patient care. However, with all of the research and potential, it is important to consider how we can appropriately implement these innovative technologies and systems into these areas, ensuring we acknowledge the technical, financial and time limitations associated with these technologies. In my personal experience, being able to see the stages of development from idea to end product, a basic understanding of what is capable and what is not allows a greater degree of creativity within these constraints. For past, current and future medical professionals, researchers and innovators, collaboration and involvement in the multiple facets of its development can be extremely beneficial in producing systems that take advantage of the technology available in solving or improving situations within healthcare. Experts of these technologies are best able to explain the capabilities and shortfalls of each level, whereas students, clinicians and patients can provide nuanced insight into the possible situations these technologies can be applied, and provide constructive feedback on their experiences using them. The bridge between academic theory and real world application of 3D printing and VR is already being crossed, with its further advancement requiring willingness from researchers, developers, engineers, medical students, clinicians and patients to participate, to learn and work together.

References

1. Ventola CL. Medical applications for 3D printing: current and projected uses. Pharmacy and Therapeutics. 2014;39(10):704.
2. Rosen JM, Soltanian H, Redett RJ, et al. Evolution of virtual reality [Medicine]. IEEE Engineering in Medicine and Biology Magazine. 1996;15(2):16-22. Doi: https://doi.org/10.1109/51.486713
3. Sun Z, Wong YH, Yeong CH. Patient-Specific 3D-Printed Low-Cost Models in Medical Education and Clinical Practice. Micromachines. 2023;14(2):464. Doi: https://doi.org/10.3390/mi14020464
4. Lau I, Gupta A, Ihdayhid A, et al. Clinical Applications of Mixed Reality and 3D Printing in Congenital Heart Disease. Biomolecules. 2022;12(11):1548. Doi: https://doi.org/10.3390/biom12111548
5. Lau I, Sun Z. The role of 3D printed heart models in immediate and long-term knowledge acquisition in medical education. Rev Cardiovasc Med. 2022;23(1):1-9.Doi: http://doi.org/10.31083/j.rcm2301022
6. Mee H, Greasley S, Whiting G, et al. 3D printed customised external cranial plate in a patient with syndrome of trephined:'a case report'. 3D print med.2021;7:1-7. Doi: https://doi.org/10.1186/s41205-021-00123-7
7. https://medicine.yale.edu/news/yale-medicine-magazine/article/a-saferthanever-joint-replacement/
8. Cloonan AJ, Shahmirzadi D, Li RX, et al. 3D-printed tissue-mimicking phantoms for medical imaging and computational validation applications. 3D Print Addit Manuf. 2014;1(1):14-23. Doi: https://doi.org/10.1089/3dp.2013.0010
9. Bezek LB, Cauchi MP, De Vita R, et al. 3D printing tissue-mimicking materials for realistic transseptal

puncture models. . J Mech Behav Biomed Mater. 2020;110:103971. Doi: https://doi.org/10.1016/j.jmbbm.2020.103971
10. Ökmen BM, Aslan MD, Yüzer GF, et al. Effect of virtual reality therapy on functional development in children with cerebral palsy: A single-blind, prospective, randomized-controlled study. Turk J Phys Med Rehabil. 2019;65(4):371. Doi: https://doi.org/10.5606%2Ftftrd.2019.2388
11. https://medicalfuturist.com/5-ways-medical-vr-is-changing-healthcare/

ACKNOWLEDGEMENT

We would like to thanks Luke Mickan from Faculty of Science and Engineering for showing us around the 3D printing lab and Carley Tillett from Curtin HIVE for demonstration of 3D visualisation facilities to us. Our appreciation also goes to Shen-Yuan Lee and Deborah Daring, the research students at Curtin Medical School for sharing their research studies with us.

Figures

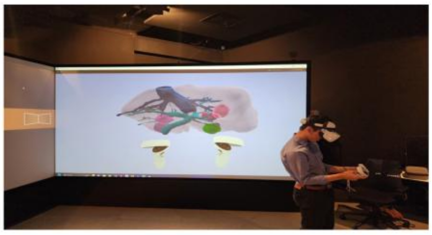

Figure 1: VR simulation of liver with multiple tumours (pink colour).

Figure 2: Stereoscopic panoramic visualisation at Curtin HIVE.

Figure 3: 3D printing laboratory with a number of Form labs form3 printers.

Received: *27-Mar-2023, Manuscript No. AMJ-23-3947;* ***Editor assigned:*** *30-Mar-2023, PreQC No. AMJ-23-3947(PQ);* ***Reviewed:*** *14-Apr-2023, QC No. AMJ-23-3946;* ***Revised:*** *19-Apr-2023, Manuscript No. AMJ-23-3947(R);* ***Published:*** *26-Apr-2023*