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# The 3 D Printing Age and Basic Sciences Education

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## ABSTRACT

Acquiring teaching resources is challenging for many medical schools, in particular the acquisition of cadavers for anatomy labs. Cadavers are not easy to store, and are costly to maintain. With three-dimensional (3 D) printing, one can create nonperishable anatomy specimens that will overcome some of those challenges. For the purpose of teaching human anatomy at University of Ottawa, highly realistic 3 D printed models (heart, kidney and gastrointestinal system) were created. Images in stereolithography (STL) format were downloaded for free from Thingverse community and printed using Makerbot replicator 2 X machines, using the makerspace facility, Faculty of Engineering, University of Ottawa. The primary advantage of this technique is its ability to create almost any shape or geometric feature. Unlike cadavers, 3 D printed models will not deteriorate so they are also cost effective. This technological development is becoming more and more popular. Eventually, it will impact every single aspect of our lives.

**Keywords:** *3 D printing, Basic sciences, Medical education*

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## INTRODUCTION

Modern medical education puts more emphasis on developing students' clinical competencies and requires a wealth of resources to achieve this purpose. Acquiring these resources is challenging for many medical schools, in particular the acquisition of cadavers for anatomy labs. Cadavers are not easy to store, are costly to maintain and must be properly disposed after a certain period of time. The three-dimensional (3 D) printing is among the new technologies that have in recent years revolutionised the medical education field and seems to offer solutions to some of the challenges (1).

The 3 D printing or AM (additive manufacturing) technologies is any of various processes used to make a three-dimensional object. In the term's original sense, it refers to processes that sequentially deposit material onto a powder bed with inkjet printer heads (2).

The virtual design is made in a CAD (computer aided design) file or with the use of a 3 D scanner to copy an existing object. The software then slices the design into hundreds or thousands of horizontal layers before loading it to the 3 D printer which follows the G-code instructions to lay down successive layers of material to build the model (3).

Printing can be done using a single or multiple materials, such as ABS plastic, polyamide (nylon), and glass filled polyamide, stereolithography material, silver, steel, and even chocolate. Those materials pass through a print nozzle. The nozzle is heated to melt the material and the object is produced by extruding melted material to form layers as the material hardens immediately after extrusion from the nozzle (2). 3 D technologies found applications starting in the 1980s, including architecture, construction, automotive, aerospace, military, and engineering, biotech (human tissue replacement), fashion, jewelry, eyewear, dental and medical industries, medical education and research, food, etc. (4).

Other applications include developing 3 D-bioprinted tissue models for research, drug discovery and toxicology (5). Printer cartridges are adapted to use stem cells obtained from biopsies and grown in cultures. The resulting substance is called Bioink. 3 D bio printing has already been used for the generation and transplantation of several tissues, including multilayered skin, bone, vascular grafts, tracheal splints, heart tissue and cartilaginous structures.

This rapid evolution of technology in daily life has shaped the modern society educational style. Virtual anatomy teaching will soon be in place; however there is nothing better than laying your hands on physical body parts to gain better insight into the human body anatomy. With 3 D printing, we can create the models needed to facilitate our teaching and deliver the information in an appealing way especially to the new generations of students who are minded by technology. Students can have a proactive role by creating the models needed for their learning.

## WHAT WAS TRIED?

The anatomy models created at the University of Ottawa (heart, kidney, gastrointestinal system and dural venous sinuses) (Figures 1, 2, 3) were printed using the makerspace facility at the Faculty of Engineering. Makerspace is a collaborative space, run by students and staff and is home to the latest in 3 D printers provided by MakerBot. The use of the space is free to students and staffs of the University of Ottawa as well as anyone who wishes to share the resources.

The files in STL format compatible with the MakerBot printing machines were downloaded for free from Thingverse website (MakerBot's Thingiverse is a thriving design community for discovering, making, and sharing 3 D printable things). Images were opened in MakerBot program, and sent to the printer which started the printing by sequentially depositing ABS material (Acrylonitrile-Butadiene-Styrene) onto a powder bed with inkjet printer heads. The models took from two hours up to eight hours depending on their size and complexity, the models were then integrated in anatomy teaching and they were well received both by medical educators and medical students.

## CONCLUSION

3 D printing is becoming more and more popular and since the start of the 21st century their price has dropped substantially. 3 D printing will revolutionise education. Bre Pettis, of MakerBot Industries, in a grand but practical vision sees a 3 D printer on every school desk in America (6).

3 D printing can be faster, more flexible and less expensive than traditional techniques when producing relatively small quantities of

parts. It can be used to create any teaching model for basic sciences education. Unlike cadavers, 3 D printed models will not deteriorate so they are also cost effective.

3 D printers will continue to improve to a point where functional products will be able to be output. With effects on energy use, waste reduction, customisation, product availability, cost effectiveness; 3 D printing will change the basic sciences education world as we know it.

**Figure 1:** 3 D printed closed heart.

**Figure 2:** 3 D printed kidney.

**Figure 3:** 3 D printed dural venous sinuses.

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