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Review Article

Changing Art of Anatomy Illustrations

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Abstract

Anatomical illustrations have gradual changed since their inception. The pioneers of the field have initially used pencil drawings, followed by line illustrations, colored illustrations, two dimensional and three-dimensional illustrations, and it grew up to virtual reality. Recent studies have observed their benefit in teaching anatomy, especially for providing spatial orientation of various structures and complex topics such as middle ear, pterygopalatine fossa, where dissection cannot offer much comprehension. Drawing software such as Illustrator and Photoshop have revolutionized the image quality in anatomy textbooks. Adobe Illustrator comprises many useful tools to draw anatomical diagrams such as pen tool, pencil tool, paint brush tool, text tool. It has various paper sizes to choose and different formats of files to create vector-based images. The drawing hardware such as Wacom Cintiq, Apple iPad Pro with pencil enhances the experience with drawing software.

Keywords: Illustrations, 3D Anatomy, Virtual reality, Augmented reality, Drawing software.

INTRODUCTION

Anatomy is a combination of art and science. The anatomy illustrations started with paintings and carvings on wood and grew up to 2D software, followed by 3D software to virtual reality. The drawing software in recent times has greatly enhanced the image quality of anatomical illustrations in the prints of textbooks. The spatial orientation of the anatomical structures is of importance for surgeons. But the conventional mode of teaching, diagrams and lectures by PowerPoint fail to teach this. The upcoming 3D software has great potential to improve learning in this area. In the background of massive technological advancement, a review of the changing art of anatomical illustrations is well essential.

Review

Eminent anatomical illustrators

Many eminent anatomical illustrators existed, starting from Aristotle, as mentioned in Table 1. Leonardo da Vinci had drawn many line drawings without backgrounds. Vesalius is the author of *De Humani Corporis Fabrica*, one of the most influential books of Anatomy. He used woodcut blocks to demonstrate the anatomical structures and sent them for printing (Netter & Friedlaender, 2014). Henry Carter produced many illustrations by wood carvings, which gained world acclaim in Gray's Anatomy. Netter produced nearly 4000 illustrations and used a variety of media for medical illustrations (Kemp, 2010; Smith, 2006). He mainly preferred opaque watercolor, or gouache paints. He used Number 2 pencil and thin tracing paper, Whatman brand smooth hot-pressed illustration boards, Porcelain palette (*Medicine's Michelangelo*, n.d.). The type of illustrations changed over time from pencil drawings to two-dimensional illustrations and then three-dimensional illustrations, presently reaching virtual reality. The transformation of anatomy illustrations has been shown in Flowchart 1.

Table 1: Eminent anatomical illustrators in the world's timeline

Timeline	*Illustrators*	*Lifetime*
400 BC	Aristotle	384–322 BC
1400 AD	Donatello	1386–1466
	da Vinci	1452–1519
	da Carpi	1460–1530
1500 AD	Eustachi	1500–1574
	Vesalius	1514–1564
	Fabricius	1533–1619
	Casserius	1561–1616
1700 AD	John Bell	1763–1820
	Henry Vandyke Carter	1831–1897
1900 AD	Netter	1906–1991

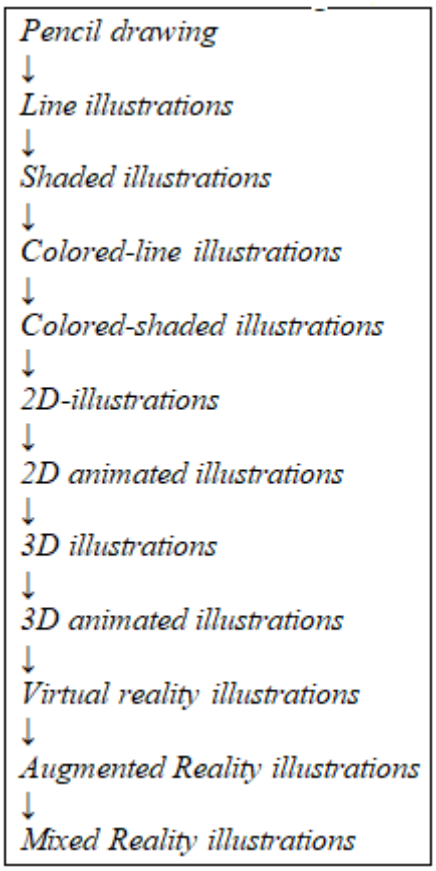

Figure 1: Flowchart showing the change of anatomical illustrations

2-D Illustration software: Raster vs. Vectors

Raster (or bitmap) illustrations are composed of pixels (tiny dots), containing unique color and tonal information. They pixelate on enlargement. The advantage of raster illustrations is that they are easy to make, any number of colors can be used, different shades can be used. Vector illustrations consist of shapes, curves, lines, and text that form a picture**.** They do not pixelate or blur on enlargement. The advantage of vector illustrations is that any number of modifications are possible**.** Photoshop, MacPaint, PC Paintbrush, Painter are the apps using rasters. Adobe Illustrator, FreeHand, MacDraw, and Expression are the apps using vectors. Canvas and CorelDRAW use rasters and vectors.

3-D Illustration software: Modelling

Autodesk 3DS Max is an all-purpose modeler for content creators. Autodesk Maya is an example of professional software. 3D software has immense role in enhancement of spatial knowledge of the structures of the human body, essential for the approach to surgeries. This can even reduce the cognitive effort to be put by the student in learning anatomy. It is of great value in teaching nervous system, middle ear structures and larynx which are difficult to teach by dissection (Moro *et al*., 2017).

Illustrations for Virtual reality (VR)

Virtual reality (VR) is a simulated experience where the person is entirely into an artificially created environment. The 3D model illustrations created in the software will be imported into another software for virtual reality, and a sequence is created as an interactive video. This utilises the head mounted lens with high resolution, stereo headphones along with motion tracking systems (Moro *et al*., 2021). A study on virtual reality of heart showed that the students who learned by virtual reality performed better in both conventional anatomical knowledge as well as spatial relations of heart (Maresky *et al*., 2019). Virtual reality is found to be efficient in improvement of learners' knowledge (Zhao *et al*., 2020).

Illustrations for Mixed reality (MR)

Mixed reality (MR) is the merging of real and virtual worlds to produce new environments and visualizations, where physical and digital objects co-exist and interact in real-time. The virtual objects are anchored into the real world thereby giving a perception of real objects (Moro *et al*., 2021). Microsoft's Hololens is great invention to Holoanatomy app is an example of this kind. A study on mixed reality and dissection of upper and lower limbs observed that the results of students after mixed reality intervention were equally effective as cadaveric dissection and more efficient in the fact that time taken for mixed reality was 3.6 hours compared with 6 hours of dissection,

cadaveric dissection has disadvantage of being costly and time-consuming, requirement of body donation, which are not needed in mixed reality (Stojanovska *et al*., 2019). Mixed reality is a viable option in the situation of scarcity of cadavers.

Illustrations for Augmented reality (AR)

Augmented reality (AR) is an enhanced version of the real physical world. It consists of a camera-equipped device such as a smartphone, a tablet, or smart glasses loaded with AR software. When a user points the device at an object, the software recognizes it through computer vision technology, which analyses the object. The person will be able to interact with virtual objects and real elements of the environment. Visible body is one project on anatomy using the augmented reality. The comparison with the normal dissection was done in the understanding of cross-sectional anatomy. The advantage of augmented reality is that it provides opportunity to dismantle the parts and assemble them back together. Dissection makes it possible to learn by cutting the anatomical structures but uniting the cut structures later is not possible (Henssen *et al*., 2020).

Drawing software

Recent advancement in technology has led to the development of drawing software which is far advanced in picture quality compared to traditional mode of drawing on paper. Illustrator and Photoshop are two examples of commonly used drawing software. It is of great potential to revolutionize the images of human anatomy which form the core base of the discipline of human anatomy. Photoshop is useful to depict the pterygopalatine fossa whereas it is difficult to demonstrate by dissection alone or by static images present in the atlas (Sinav & Ambron, 2004).

Drawing hardware

Wacom Cintiq, Apple iPad Pro with pencil, Huion Pro, HP x360 Pavilion with pen, Microsoft Surface Pro with pen are some examples of hardware which have showcased amazing user experience. They combined the great image quality of software with traditional and easy way of drawing with hand. The outline of drawings are smoothened by the hardware transforming the common man into an artist.

Illustrator

Illustrator is a drawing software of great benefit to anatomy. The document can be created in various formats such as letter, postcard, A4 sizes. The colours can be selected to be in grayscale, RGB or CMYK format. The line diagrams can be drawn with the tools of pen or pencil, with provided stroke colour and fill colour. The shapes can be drawn with help of shape builder tool. The diagrams can be placed in layers one above the other. The labels can be inserted beside the diagrams with the help of text tool. The diagram can be zoomed in with help of zoom tool and can be moved with help of hand tool. At the end, the art can be exported in the format of JPEG or PNG (*Default Keyboard Shortcuts for Illustrator*, n.d.).

CONCLUSION

The advancement of technology has led to reaching new dimensions in the illustrations of anatomy. 3D teaching software are of great value in providing the spatial anatomical knowledge, enhance the engagement of students, provide ease of learning, and teach difficult topics. Various studies conducted show the benefit of the software in learning anatomy and efficiency as less time is required to impart the knowledge compared to conventional dissection. The drawing software such as Illustrator provides a huge artistic help to any teacher of anatomy to create images with great quality with ease and enhance the understanding of anatomy.

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