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Medical Illustration in the 21st Century and beyond

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Abstract

This paper provides an overview of contemporary medical illustration; the role of the modern medical illustrator is examined, including who they are likely to work for and with, as well as the range of media and technology employed. The various applications of medical illustration are described with a focus on looking to how these are likely to change and develop in the near future.

What is Medical Illustration anyway?

"As art reflects culture, scientific illustration reflects the findings of science and technology. Science illustrators are artists in the service of science. They use scientifically informed observation, combined with technical and aesthetic skills to accurately portray a subject. Accuracy and communication are essential."

Guild Handbook of Science Illustration, ©GNSI 1989, 2003

Although artists have depicted anatomy and medicine for thousands of years (descriptions of anatomy, medical practice and surgery dating back to the ancient civilisations of Egypt and Greece were accompanied by contemporary artistic depictions), Medical Illustration as a modern profession is often said to have begun with the work of Max Brödel. Working first in Germany, he produced illustrations of gross anatomy along with histological diagrams for Dr. Carl Ludwig, Director of the Institute of Physiology and Anatomy at the University of Leipzig. There he met Dr. Franklin P. Mall, an anatomist from the Johns Hopkins Medical School. In 1894, after accepting an invite from Mall, Brödel moved to Baltimore, Maryland to become the first medical illustrator employed at Johns Hopkins University, where in 1911, the Department of Art as Applied to Medicine opened with Brödel as its director. This was the first academic programme of its kind in the world, training students with the knowledge and skills required to become professional medical illustrators.

The 20th century went on to see the founding of several professional bodies for medical illustration. The first of these being the Association of Medical Illustrators (AMI), founded in the US in 1945, closely followed by the Medical Artists Association (MAA) of Great Britain in 1949, and more recently the Institute of Medical Illustrators (IMI) in the UK, in 1968.

Medical illustration today encompasses a range of applications and media. More traditional 2D illustrations are still produced for textbooks and patient information pamphlets, but increasingly digital media is being used to create resources such as 3D animations for e-learning applications and even interactive models that can be viewed in virtual reality. Medical illustration is considered a form of scientific illustration, and medical illustrators are generally regarded to be artists working in the service of medicine.

The modern medical illustrator

It is the role of the medical illustrator to communicate often complex scientific information and concepts to a broad range of audiences through visual media. To this end, the modern medical illustrator should be educated to an advanced level in both anatomy and visual communication. While some train first as artists and illustrators, others come from backgrounds in science and medicine, with each typically learning the other when they go on to specialise in medical illustration, usually at Master's level. While there is no legal requirement in the UK or elsewhere to undertake specialist or accredited programmes, it is generally regarded as best practice. In the UK, medical illustrators are encouraged to join the Academy for Healthcare Science (AHCS)

Medical Illustrator Register, which requires the completion of an accredited degree programme. Similarly, in the US the Commission on Accreditation of Allied Health Education Programs (CAAHEP) accredits a number of medical illustration programmes in North America.

There are several professional bodies that medical illustrators can join, such as the AMI in the US and the IMI and MAA in the UK. Joining a professional organisation such as these offers a range of advantages to medical illustrators, whether they are employed or working freelance. Firstly, there is the sense of community and networking that comes about through conferences and regional meetings. Such face to face events also provide opportunity for continuing professional development (CPD), something which is essential to those wishing to join a register such as that held by the AHCS. Most professional bodies also produce guidelines in terms of professional practice and ethics. These are of utmost importance as this is profession where individuals may have access to patients and their data, as well as to anatomical human material. An understanding of the responsibilities and laws around subjects such as data protection and anatomy legislation are therefore essential.

Medical illustrators work for a variety of employers. These typically include organisations such as the NHS, private hospitals, medical schools, research institutions, publishers, as well as specialised medical illustration companies. More recently, medical illustrators are also being employed by e-learning companies, software and app developers, and even VR developers. In addition, a sizable proportion of the profession are self-employed, working with clients such as medical professionals and publishers directly. As a result, medical illustrators are often part of a

diverse team and complex workflow. It is important therefore that they can communicate clearly with other professionals, be they medical staff, educators, computer programmers, or publishers.

Media and technology

Traditional media

Despite the proliferation of digital media, many medical illustrators still incorporate traditional media into their work. For some this forms a part of a larger workflow (such as preparatory sketches) which ultimately results in a digital piece of work, whereas for others, traditional media is still used alongside or even in preference to digital for the final piece. Traditional media can itself take many forms of course and includes a range of 2D approaches such as drawing and painting as well as 3D modelling in materials such as clay, wax and silicone. Those who use traditional media for all or a part of their work, often cite a preference for it due to the tactile feedback it can provide along with certain effects that can be difficult if not impossible to replicate with digital media. In addition, using a medium such as watercolour can be beneficial when depicting particularly graphic or sensitive material as it can 'soften' the image and make it less disturbing, especially for a lay or patient audience. Medical artist Joanna Culley frequently uses both watercolour and pencil media in addition to digital. Figure 1 shows an example where the client requested the illustration be created in pencil so it could be used within an animation to "reflect a softer look and 'feel' to the illustrations…. Graphite pencil was the preferred choice to depict the properties of the IUD and the insertion procedure along with the female anatomy

so that it would seem more appealing to those patients watching the animation."

(https://www.medical-artist.com/portfolio/frontera-pencil-medical-illustrations/)

[Place figure 1 near here]

2D digital illustration and animation

2D digital illustrations are the staple work for many medical illustrators. They are regularly used in medical and anatomical textbooks, as well as in presentations at medical and scientific conferences, and for posters and leaflets containing patient information. The majority of 2D illustrations now produced using digital software such as Adobe Photoshop and Illustrator. The benefits of such software are numerous; they provide a vast array of tools and effects within a single application, allow illustrators to easily undo mistakes, and the resulting illustrations can often be edited and repurposed for future projects. 2D illustrations can be produced in a variety of styles and at different levels of realism for various target audiences. They can range from simple black and white line illustrations to full colour realistic depictions, or even cartoons and 'Graphic Medicine'[1] comics.

In addition to 2D illustrations, 2D animations are also useful for conveying certain types of information. They are often used for subjects that don't require an understanding of 3D spatial relationships, or for conveying complex concepts in a simpler manner. They are best combined

[1] https://www.graphicmedicine.org/

with a voice over (as opposed to subtitles) as this can help guide the narrative and aid in highlighting important features. They are often less time consuming to create and therefore cheaper to produce than many 3D animations. As with illustrations they can be created in a range of styles from simple to highly realistic.

3D digital modelling and animation

Over the past two decades there has been a proliferation of 3D software enabling artists to create complex 3D models and animations. 3D models can either be based on scan data, such as MRI, CT, and surface scans, or created from scratch within the software itself. 3D digital models have a range of uses; they can be embedded as interactive models (that allow the user to rotate, zoom, and read annotations) in webpages, virtual learning environments, eBooks and iBooks, as well as in interactive PDF documents. In addition, they can be used as 'assists' when creating animations or educational games and applications. They can be viewed and interreacted with in virtual reality (VR) and even 3D printed.

3D animations are very popular and, when done well, have the potential to convey a large amount of information in a short space of time. They are particularly useful for topics that require an understanding of 3D spatial relationships, and where a narrative, or sequence of events is important. As with 2D animations, they are best paired with a voiceover to help guide the viewer in what they are seeing and what to look out for. However, 3D animations can be time consuming and therefore expensive to create.

Applications of Medical Illustration

Medical and anatomical education

Medical and anatomical education is one of the primary applications of medical illustration, both in the past and so it remains today. Traditionally, medical illustrations have featured prominently in anatomy and medical textbooks. It could even be argued that some of these books (such as Vesalius's *'De humani corporis fabrica'*) are known more for their artwork than for the accompanying text. Such textbooks are still a mainstay of medical education, featuring modern 2D illustrations, often produced digitally as described above. In addition however, are a new wave of educational resources, aimed at engaging students who are used to seeking information digitally online and via apps. These include commercially available software programmes, mobile apps, e and iBooks, animations, and websites, as well as bespoke resources made 'in house'. E-learning is a growing field as it can provide students with access to approved learning resources remotely. As such, a number of medical schools now employ e-learning technologists along with medical artists to create visual learning resources for use online, as in the example in figure 2 created by the author for the University of Dundee. It is important to note, that when creating such resources, medical artists work closely with subject area specialists in order to understand the key learning objectives that need to be communicated. Medical artists working in medical education should also have a good understanding of research surrounding learning styles and theory in order to apply these to their work.

New technologies such as virtual and augmented reality are also starting to be used in medical education. These are discussed in more detail below.

[Place figure 2 near here]

Patient information

The other primary application of medical illustration is patient information. Traditionally this has largely consisted of illustrations and design for 2D posters and leaflets. While these are still used, as with medical education, there is a growing demand for information to be accessible in digital formats and online. It is well documented that patients often 'google' their symptoms or conditions in order to find out more information without the need for a doctor's appointment (1). The results of such activities can be varied, due largely to the differing quality of information available online. However, research by Briggs et al (2) demonstrated that when patients were provided with access to high quality digital resources (in this case a series of three iBooks, containing written information along with interactive diagrams, 3D animations and interactive models), they no longer felt the need to seek further information from external sources, such as the internet. This demonstrates the importance of good quality and readily accessible patient information. For this reason, many organisations such as the NHS and medical charities have their own webpages where they can guarantee the quality and accuracy of the information provided. Illustrations, animations, and 3D models can enhance these online resources making them easier to understand and more accessible to a range of audiences.

When considering the best format (paper leaflet, interactive PDF, e and iBooks, website etc) to use for patient information, the medical illustrator needs to think about exactly who the target audience is likely to be, i.e. adult, child, elderly, visually impaired etc. As the this may impact both the format and style chosen, as well as the level of detail included (3).

Other applications

In addition to medical education and patient information, there are a range of other applications that utilise medical illustration. These include; medico-legal artwork in the form of illustrations, models and animations as demonstrative evidence and trial exhibits for accident and medical negligence cases; pharmaceutical advertising in brochures, television and at trades shows; science peer to peer communication, such as illustrating journal papers and conference presentations; and for public engagement if the fields of medical and life science research.

The future of medical illustration and visualisation

In terms of what the future holds for medical illustration, a major driver will be recent and ongoing developments in technology. Imaging technologies such as medical and 3D surface scanners can capture higher resolutions of detail than ever before, likewise modern 3D modelling software packages are able to handle complex models and render objects with highly realistic material properties. Developments in image capture and creation technologies are

already being combined with new and evolving distribution methods (some of which have been described above), including: e and iBooks, interactive PDF's, online 3D models, and mobile apps.

In addition to these, Virtual and Augmented Reality technologies are being investigated by a number of medical schools (4–8) as a means of further engaging students with virtual models. 'Virtual Reality' (VR) refers to a fully immersive experience using a head mounted display (HMD) where the user can interact with a digital object or environment. The term Augmented Reality (AR) is currently used to describe a range of experiences, including the use of QR codes to trigger the launch of additional web-based information, including images and models, usually on mobile devices, as well as HMDs such as the Microsoft HoloLens. Unlike the HMDs used for VR, AR HMDs show the virtual scene overlaid with reality. This has the benefit of allowing the user to interact with both the digital and real world simultaneously.

Both technologies demonstrate great promise for the future of medical and anatomical education in particular and may even find their way into other applications such as patient information and medico-legal exhibits. Currently however, most students don't have access to good quality VR and AR HMDs at home. This may change over the coming years however, as more affordable, standalone VR headsets such as the recently released Oculus Quest, become more readily available.

Finally, it is worth saying something about representation in medical illustration. Parker et al (9) in their 2017 paper 'A visual analysis of gender bias in contemporary anatomy textbooks'

explored the ratio of female and male representation in contemporary anatomy textbooks and found that out of the 17 textbooks examined (consisting of a total of 6004 images) only 36% of the images with an identifiable sex were female. In addition, other forms of bias were also found, including: “the visualization of stereotypical gendered emotions, roles and settings; the lack of ethnic, age, and body type diversity; and in the almost complete adherence to a sex/gender binary”. This is a major problem when it is considered that these textbooks are used to educate our future healthcare workers. Rather, medical students (along with nurses and other allied health professionals) need to be prepared for the diverse range of patients they are likely to encounter in their working lives. It is the responsibility of everyone associated with the production of such material, including medical illustrators, to consider how to address this issue in the future.

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Conflicts of interest

The author declares no conflicts of interest.

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Figure legends

Figure 1. Illustration by Joanna Culley, demonstrating the use of graphite pencil to depict the IUD and insertion procedure along with the female anatomy, in a style that would be more appealing to patients watching the animation.

Figure 2. An example of a 3D interactive model (of the muscles of the hand), created by the author for use in e-learning, hosted online at Sketchfab.com (https://skfb.ly/6GWXx)