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Using videoconferencing to deliver anatomy teaching to medical students on clinical placements

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ABSTRACT

Medical students are classically taught anatomy towards the start of their medical curriculum, typically in their first and second year of study. During this phase of training, most of the teaching hours are delivered on site at a higher education institution rather than a clinical setting. The number of hours of anatomy teaching delivery then tends to fall sharply as these students enter their 'clinical phase', where they are mainly taught in clinical healthcare settings. As the students are then dispersed across multiple sites, anatomy teaching delivery becomes more challenging. On occasion, students may be able to return to central anatomy facilities, but when this is not possible, technology enhanced learning (TEL) can become invaluable.

In this article, we would like to share our pilot of using videoconferencing technology to co-deliver teaching sessions for students on clinical placement. We describe two examples of teaching sessions run using the 'Microsoft Surface Hub', linking between the clinical placement sites at Bristol Medical School and the Centre for Applied Anatomy. We hope by sharing our experience and showing the advantages of using this technology to bring the anatomy and clinical components together, whilst acknowledging its limitations, we will encourage others to trial new and innovative methods of exploring anatomy teaching delivery in the distributed medical education models seen during the clinical years of medical undergraduate training.

1. Introduction

1.1. Anatomy delivery in UK medical schools

Anatomy is a subject core to all medical curricula, as a sound knowledge of anatomy underpins future clinical practice [1,2]. The paramount importance of maintaining an understanding of anatomical knowledge throughout clinical training is clear and without this, there is a risk of error in clinical practice due to anatomical miscomprehension, and ultimately potential for harm to patients [3].

The General Medical Council (GMC), as the regulatory body for delivery of medical education in the UK, states in section 22 of the document 'Outcomes for Graduates' (2018) that, "*newly qualified doctors must be able to apply biomedical scientific principles, methods and knowledge to medical practice and integrate these into patient care. This must include principles and knowledge relating to anatomy* …" [4]. The GMC does not however stipulate the course content in detail, neither in terms of delivery time nor location of the teaching within the programme, leaving this to the discretion of the host institution. The Anatomical Society looked to address course content in their 'core regional anatomy syllabus for undergraduate medicine' which was revised and republished in 2016 [1]. This offers a set of clear learning outcomes for medical anatomy, but does not give guidance about methodology or timing of teaching delivery.

The overall reduction of the time available for anatomy teaching has been one of the biggest influences on medical anatomy education for many decades [5–8]. In 1992, a review of undergraduate medical anatomy by the Anatomical Society recommended there should be 300 h of delivery time for anatomy within medical programmes [9]. However studies have shown this has not been the case since the 1960s [10]. By the 1970s, average teaching hours were being reported to have fallen to around 200 h, and by the 1990s dropping further to around 165 h [10]. Anatomy, alongside the other biomedical sciences, continued to be criticised by the GMC for being too didactic and detailed in the delivery of factual content, and further medical curriculum reform led again to a real-time reduction in the number of hours dedicated to the delivery of anatomy with medical programmes [5]. In 2005, Peterson et al. reported that anatomy teaching hours were circa 135 h [11].

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With the apparent flexibility of the guidance at an international and national level, combined with the reduction in teaching hours, it is unsurprising that the delivery of medical anatomy varies considerably across institutions. Anatomists have had to devise new, effective and efficient teaching methods to teach this core discipline to undergraduates. However, there continues to be little consensus on the 'best' way to teach anatomy and it is suggested that published articles often 'serve to endorse the authors own particular "brand" of teaching … ' [5]. Indeed, some think that even future studies are unlikely to prove conclusive regarding one methodology for the delivery of anatomy over another [8]. Each institution must measure their teaching approach against the availability of facilities, financial constraints, contact teaching hours, and the local staff expertise and teaching preferences.

Most anatomists will contest that using real-life human tissue either through dissection or using prosections is of great benefit, due to the positive effects of seeing normal anatomical variation between individuals, versus the classical appearances seen if using models and textbooks alone [12]. However, even as the original 'gold standard', teaching using cadavers is resource intensive. Student-led cadaveric dissection is no longer the preferred method of teaching at many institutions, due to the high cost, technical demands, availability of cadavers and the reduction of hours within medical curricula for teaching anatomy [5,13]. Plastinated specimens can offer an alternative option to 'wet' cadaver laboratories [14]. This relatively new technique, developed by von Hagens in 1977 [15] as a specialised way of preserving prosections, does give the user the experience of using real tissue and viewing anatomical variations [3], however as the specimens are fixed and hardened these may be seen as more akin to models than real cadaveric tissues. We are also increasingly seeing the use of digital anatomy teaching alternatives, such as computer assisted learning packages [16,17], podcasts [18,19], virtual dissection tables [20], 3D and virtual reality (VR) systems [3,21,22] (see also section 1.3). Often used to supplement anatomy lab-based teaching, digital resources can be invaluable in supporting student learning [16].

Anatomy tends to be primarily delivered towards the start of the medical curriculum, typically in years 1 and 2 [6,8]. One of the problems with this model of delivery of anatomy is the science can become more easily divorced from the reality of clinical practice, with newly qualified doctors reporting that they had forgotten what was important by the time they were on clinical placements, and that the content lacked relevance [23]. Many medical schools, including Bristol Medical School, have sought to reduce this artificial split between the 'preclinical' and 'clinical' phases, offering a more 'integrated curriculum' with the biomedical sciences delivery spread 'vertically' across the programme. The anatomy is interwoven as a spiral curriculum, with increasing levels of both the complexity of anatomical detail and clinical content over time. This aims to continually build on the student's ability to understand the subject but remains focussed on the relevance of the material for future practice.

This vertical integration of anatomy has been shown to be desirable, as the approach promotes deeper learning, and aims to provide the appropriate anatomy at the most relevant time of delivery within the programme [8,24]. However, setting this up can be labour intensive, as it requires significant buy-in from the teaching staff across both clinical and non-clinical settings, and sharing of expertise [25]. A further challenge with this approach is the location of the students themselves. As they disperse across their clinical placements, the anatomy teaching delivery becomes more challenging. It is in this scenario, where face to face hands-on anatomy is not possible, technology enhanced learning (TEL) can become invaluable.

1.2. Distributed medical education (DME)

With the creation of medical schools with multiple dispersed sites, in the last 15–20 years there has been increasing investment in technology that can deliver medical education across multiple locations at one time [26,27]. Distributed Medical Education (DME), in its broadest form, links together separate branches of whole medical schools, particularly in rural locations where medical schools and medical training are less frequently located. DME can also be delivered at regional medical campuses (RMC), which are those sites away from the main medical school where medical education is received [28].

Within these models finding ways to deal with geographical separation is challenging. In some models, the management and delivery of the teaching may be handed over to a nominated team at the local campus. Others may use technology to bridge the distance, bringing together regional and central campuses using advanced audio-visual interactive technology [27]. To run these systems effectively, significant investment needs to be made by the institution in lecture theatre and laboratory spaces to provide sites with videoconferencing capabilities. The impact of potential technical difficulties also needs to be considered, as this can be highly disruptive to the learning experience [29]. Where this has been done well, evidence and feedback shows that distributed delivery of teaching is as effective as that from a live experience [27].

Studies have looked at the effectiveness of the delivery of, for example, webinars, or webcasts of lecture materials to students on clinical medical placements, and found the satisfaction and performance of learners to be comparable [30]. Whilst the use of DME is common in modern medical schools, the way in which technology is used *within* this model is variable, and there is still some concern that this type of learning can end up being passive if set up for students to work through independently, with limited interactivity [18].

1.3. Technology enhanced learning (TEL) in anatomy

Anatomy has been utilising TEL to enhance teaching delivery for many years, but there has been a particularly significant rise more recently in the number of ways technology has been integrated into anatomy teaching [31]. This comes in a huge variety of forms, both in face-to-face teaching and self-directed learning scenarios, and includes online resources, using software to construct virtual 3D models from radiological images [16], 3D imaging displays and virtual reality (VR) [32], virtual dissection tables [20], social media, and 3D printing to name just a few [33].

Virtual reality systems have developed exponentially over the past few decades with systems using both headsets and specialised screens for allow the viewer to 'interact' with virtual 3D anatomy models. These technologies have been shown to engage the students and that they find these 'enjoyable' and 'fun' [22,32]. However, they are not without their disadvantages. Whilst VR systems do offer an immersive experience, there is still not direct contact with the material, so the true sense of the 3D nature of tissue is lost, and some individuals report undesirable symptoms during use such as headache, dizziness and blurred vision [21,22]. The systems require investment and hardware so are restricted to specific campus sites and due to the individualised experiences of these technologies large cohorts cannot learn in the same way at the same time. This latter issue is also true of the virtual dissection tables, where only small groups of students can use the equipment simultaneously [20].

This rapid progression of the use of TEL in anatomy has been important, firstly to secure anatomy as a 'modern' science, and secondly it has allowed anatomy departments to work on some of the challenges presented by curriculum change and reduction of teaching hours [31,33]. However, despite all of these advances, many of these newer technologies still require the student to be present at the anatomy facilities to use the specialised equipment, and thus a different adaptation must be sought for developing anatomy teaching during DME when students are away on clinical placement. Many TEL techniques can support the delivery of DME. This can take the form of self-directed learning in the student's own time, asynchronous distance education, or delivered interactively, with the instructor and students present at the

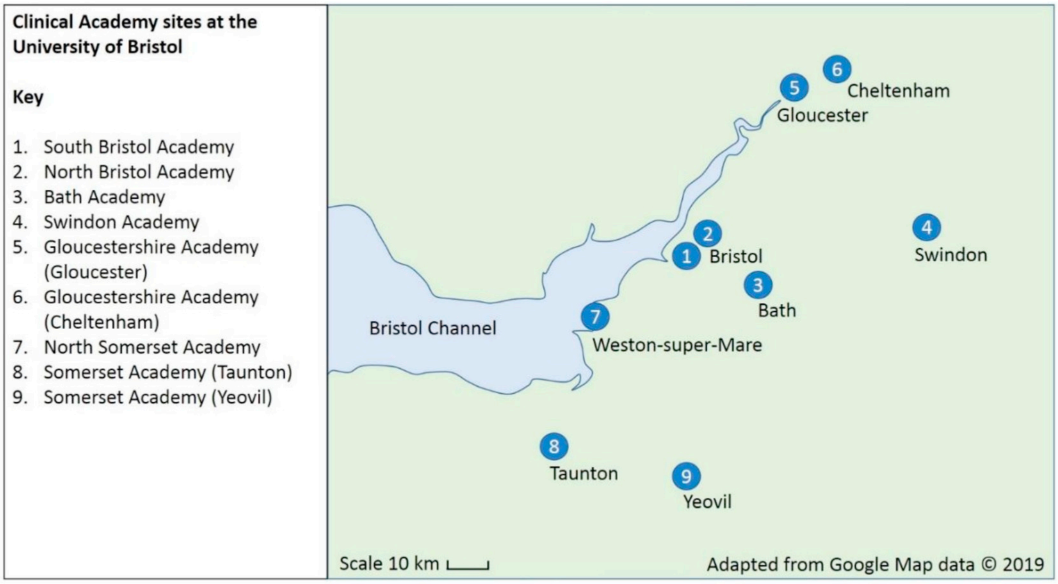


Fig. 1. Map of Bristol medical school clinical training sites – 'Clinical Academies'. Image produced adapted from Google Map Data and reproduced from Bristol Medical School Website [38].

same time, synchronous distance education [29]. Whilst forms of asynchronous distance education have been shown to be beneficial for student learning [17,19,34], by using advanced audio-visual technology, synchronous distance education has the advantage of enabling educators at one site to deliver interactive teaching to multiple sites in real-time, one of the challenges of DME.

An example of this in anatomy is the 'Prof-in-a-box (PiB) system' reported by Moorman in 2006 [35]. This system allowed students to be supported in the cadaver lab by an expert at a separate location via an interactive audio-video link. Initial feedback on the system was positive, as the system provided an environment where questions could be answered, and anatomical structures identified 'at a distance' in real-time. This type of system may also address the issue of the lack of availability of expertly trained anatomy staff seen at some institutions [35].

It must be acknowledged however, that TEL techniques are not able to offer the same haptic 3D experience of the dissection room or prosectorium, even when using VR systems. However, there is value in the provision of high-quality resources to supplement and guide the student experiences with patients, by supporting their understanding of the underlying anatomical principles.

1.4. Medical anatomy teaching at Bristol

Anatomy teaching at Bristol Medical School is led by the team at the Centre for Applied Anatomy (CAA). The Centre is specialised in its provision of anatomical expertise to three professional programmes, Medical, Dental and Veterinary Medicine, running its own Applied Anatomy BSc and intercalated honours programme in Functional and Clinical Anatomy, as well offering postgraduate studies programmes and courses. A skilled team of educators, with both anatomical and clinical experts, design the medical anatomy teaching programme, which is mainly delivered in the first two years of the medical programme [36].

In 2017, Bristol Medical School started a phase of medical curriculum review, known as 'MB21' [37]. The new curriculum moves away from a systems-based curriculum towards a case-based one, with the biomedical sciences taught throughout the five years, embedded within these cases. One of the new 'helical themes' within the programme embeds the biomedical sciences, including anatomy, throughout training. Anatomy teaching delivery remains highest during the first two years, as in the previous 'MB16' curriculum, but the later years have a higher focus than before, by vertically integrating anatomy into the case-based learning across year 3–5.

The anatomy teaching during year 1 and 2 takes the form of a series of lectures and practicals based around our prosected cadaveric materials, supported by online learning packages and self-directed learning resources. Teaching moves progressively from a foundational introduction, through systems-based anatomy in the year 1 case-based learning, to anatomy delivery structured around symptomatology in the year 2 case-based learning. Correlations to clinical practice are given throughout, including links to radiology. This clinical content increases as the course progresses towards year 3, with explanation of the relevance of anatomy for radiology, pathology, clinical examination and the safety of clinical procedures.

Moving to the future, as the MB21 curriculum review enters years 3–5, it is envisioned that this phase will focus again on the anatomy of clinical examination and procedures, building on the knowledge gained in year 2, mapping onto the case-based learning, and by year 5, the entrustable professional activities (EPAs). It is predicted that anatomy teaching during this phase will be delivered using a combination of face-to-face anatomy learning and online resources.

2. The challenge

2.1. Delivery of anatomy teaching to students on clinical placements

Anatomy teaching delivery during the early years, as mentioned above, is logistically easier as the students tend to be placed locally at the host institution. However, as the students progress through their training, their clinical placements are longer, and the locations of these may stretch across the entire region linked to the medical school. At the University of Bristol, after year 2 the students are placed throughout the region surrounding the City of Bristol at the 'Clinical Academies' (see Fig. 1).

These examples of RMCs deliver linked education across the sites, with central instruction and devolved management for delivery of teaching via the 'Academy Deans'. The students do not return to the central campus, where the main anatomy facilities are located, during their placements of up to 12 weeks, thus face-to-face anatomy teaching delivery by the CAA becomes increasingly difficult.

The challenge is therefore to create high quality real-time anatomy teaching that integrates with the students clinical learning, in a setting with opportunities to ask questions, and can be offered across the network of clinical sites to offer parity of experience to all students.

3. A potential solution: a pilot of interactive videoconferencing

During the implementation phase of the MB21 medical curriculum at the University of Bristol between 2015-17, the structure of how, when and where the biomedical sciences would be taught within the curriculum was restructured. The new curriculum would require the teaching of case-based learning across all the Clinical Academies, with linking not only between Academies but also with the biomedical science departments, such as the CAA, on site at the University of Bristol central campus. An investment in the advanced digital technology required for delivery of this DME across the RMCs was needed. Bristol Medical School, in partnership with the University of Bristol Information Technology (IT) Department, sought out a solution from Microsoft in the Microsoft Surface Hub.

3.1. Microsoft Surface Hub

The Surface Hub is a type of interactive digital whiteboard developed and produced by Microsoft [39]. The Surface Hub runs on the Microsoft Windows 10 operating system and features familiar Microsoft Office applications such as PowerPoint, Word and Excel. It also has Skype for Business preloaded with its own, University configured Skype account, which means it can be readily used to videoconference to another Surface Hub or Skype user. The simplicity of the interface (Microsoft Office 365), ease of use and familiarity of the system made it an excellent tool for the pilot [40], coupled with the ability to easily connect to other sites and use it for interactive teaching or presenting locally or remotely. The 55” Surface Hub screen supports 1920 × 1080 resolution in high definition and has wide-angle HD cameras and microphones on both sides of the screen. All this high-quality technology is very well suited to displaying high resolution medical images (see Fig. 2) and presenting from one Surface Hub to another.

During the summer of 2016, Bristol Medical School bought four 55” Surface Hubs to use in a pilot. Two of the Surface Hubs were placed in regional teaching hospitals, and two on the University campus, one in the CAA and the other in the School of Physiology and Pharmacology. The pilot was to explore and develop new and innovative teaching and communication techniques to support science teaching for students on placements at the Clinical Academies (see 2.1). The Medical School wanted to investigate how the videoconferencing and whiteboard capabilities of the Surface Hubs could be used to:

- Bring science teaching from campus to an Academy or group of Academies
- Provide teaching from one Academy site to another in order to bring specialist clinical expertise into an Academy where it is missing and thus exploiting the strength of our Academy model
- Enable clinical expertise to be delivered from an Academy to teaching sessions on campus
- Bring in external national/international expert for TED-Ed presentation or teaching

It may be noted that videoconferencing is not new technology. Indeed, these techniques have been used across business and education sectors for many decades. This pilot was not seeking to create or develop a new technology, but using the latest software and hardware advances, was aiming to repurpose videoconferencing in an innovative way of delivering medical education at Bristol.

We report on two case studies of teaching sessions developed using the Surface Hub to tackle the first two of these objectives, linking the CAA with the Clinical Academies to integrate anatomy into clinical placement tutorials. These were not run as research studies with data collection, but rather as pilots of the technology in action with three small groups of medical students (one group for the session in year 2 (n = 6) and two groups for the session in year 3 (n = 60)). We are reporting on our experiences of the intervention. The students were not surveyed after these sessions, but qualitative comments were collected to see their viewpoints, and examples of these comments are shared.

3.2. Case study 1: Neuroanatomy – the applied anatomy of Stroke

3.2.1. Session design

This teaching session was designed by collaborators at the Centre for Applied Anatomy (CAA) and a local NHS hospital at one of the Clinical Academies. A group of six year 2 students on clinical placement at the hospital were recruited to take part in the pilot. These students

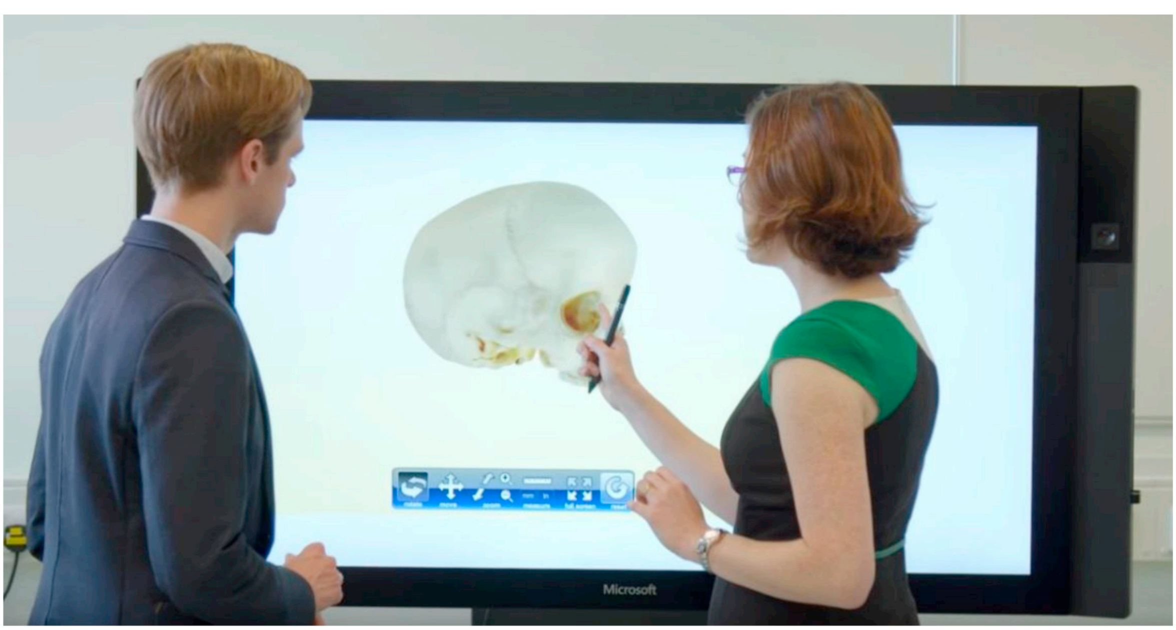


Fig. 2. Dr Michael Hollifield and Dr Sarah Allsop pictured (L–R) using the Microsoft Surface Hub to display a virtual 3D interactive skull model. Image reproduced from Microsoft and the University of Bristol's video, ‘Surface Hub: University of Bristol Medical Students Use Surface Hub for Global Collaboration’ [41].

Time	Session
14:00-14:30	Anatomy Centre: Anatomy of brain lobes and functions, upper versus lower motor neurone signs
14:30-15:00	Peripheral Hospital: Learning the basics of neurological examination (Limbs)
15:00-15:30	Peripheral Hospital: Patient history and examination
15:30-16:00	Break
16:00-16:30	Peripheral Hospital: Basics of neurological examination (Cranial nerves)
16:30-17:00	Anatomy Centre: Anatomy of Circle of Willis, artery territories, classifying stroke

Fig. 3. Neuroanatomy - Applied Anatomy of Stroke Session. Details of the session structure and timings, delivered jointly between the peripheral hospital and anatomy centre teachers via the Surface Hub.

had completed their neuroanatomy basic sciences block earlier in their second year and were now off site from the university and away from the anatomy facilities. This small group were due to have a teaching session on stroke and it was considered that the content of this session would lend itself well to piloting the Surface Hub technology to link the anatomy and clinical aspects together.

The aim of the session was to link previously attained neuroanatomy knowledge with its clinical application relating to stroke, and to understand the importance of lesion localisation in neurological history-taking and examination. The session was run by a Clinical Teaching Fellow (CTF) at the hospital site and two medically qualified anatomy teaching associates at the CAA using videoconference calling (Skype for Business) using the Surface Hubs at both sites.

3.2.2. Session structure

The session was focused around a patient with a past medical history of stroke, who was consented to attend. The session was run over 3 h, including a 30-min break (See Fig. 3).

The students, as a group, took a basic history from the patient, facilitated by the CTF. There was a debrief of details elicited from the history discussed collectively between the patient, CTF, students and anatomy teaching associates. The neuroanatomical basis of this patient's history and examination findings was interwoven into the session in short tutorials using a PowerPoint presentation on the software loaded on the Surface Hub. Interactive slides were presented, which the students could then work on as a group using the Surface Hub's whiteboard function to annotate and draw diagrams, complete tables etc (see Fig. 4). For the clinical examination component, the CTF examined the patient and demonstrated the main clinical signs to be found, followed by a similar debrief around the Surface Hub with further PowerPoint based tasks.

The Surface Hub's interactive whiteboard allowed students and the CTF to annotate slides from the hospital side, whilst the anatomy teaching associates could observe their work at the CAA, verbally making corrections via the videoconference call function, as required. The whiteboard could also be shared from either side, i.e. from hospital to anatomy and vice versa. This 'board-casting' allowed both sites to view written annotations to the screen and those at the remote site to make visible corrections as well. To follow up from the session the slides were shared with the students via email.

3.2.3. Session observations and feedback

Feedback from the students was positive, with all students rating the session as 'Excellent'. Comments included:

- 'Really useful to be able to examine a patient and then discuss the findings in detail and relate it back to anatomy'
- 'Clinical signs and anatomy teaching taught by demonstrators who know our level of knowledge in neuroanatomy'
- 'Useful to have patient and teachers both here, in clinical academy, and in anatomy'
- 'Useful being able to have group discussion with familiar teachers knowing our year 2 anatomy syllabus'

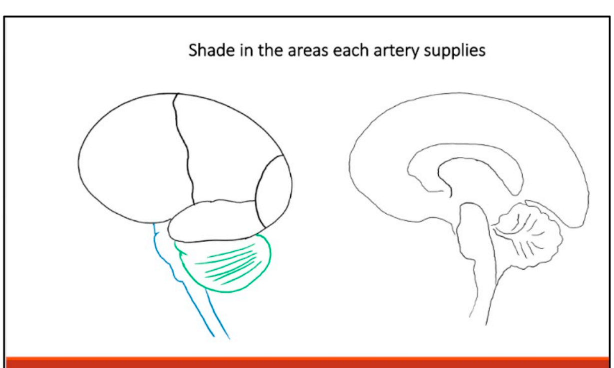
3.3. Case study 2: Applied anatomy of general surgery for medical students

3.3.1. Session design

Medical school surgical rotations involve medical students rotating through general surgical, urology and vascular placements. These are prime examples of rotations where the utilisation of anatomical knowledge attained from the pre-clinical phase of studies will underpin effective learning. A teaching session was constructed, which could be implemented via the Surface Hub, based upon aspects of general surgery, and the clinically applied anatomy associated with the key concepts. The main aim was to revise essential aspects of abdominal anatomy to equip the students with the necessary anatomical knowledge to help them succeed in their placements.

3.3.2. Session structure

The 30-min sessions were delivered via the Surface Hub, by two medically qualified anatomy teaching associates based at the Centre for Applied Anatomy (CAA), to student groups in an NHS hospital at the



Instructions given to students

- Given a diagram of the brain in multiple views, annotate the major lobes and divisions, add each region's functions
- Superimpose vascular territories onto this diagram

Fig. 4. Example of slide materials from the teaching session, Neuroanatomy - Applied Anatomy of Stroke.

Clinical Academies where their rotations were taking place. The students were facilitated on the hospital site by a CTF, who could direct queries to the anatomy staff as needed. The session was delivered on two occasions, each time to a group of 30 students in the third year of their medical studies, who were about to embark on their first clinical rotations in surgery. The content of the presentation included:

- Gross topical anatomy and surface landmarks of the abdomen - skeletal and visceral
- Abdominal planes, quadrants, regions, contents plus neurovascular and lymphatic supply
- Layers of the anterior abdominal wall - addressing the arcuate line and clinical relevance
- Anatomical basis for referred pain in the context of the acute abdomen
- Examination findings in the surgical placement - hernia, right iliac fossa pain, right upper quadrant pain, stomata

The session involved the presentation of PowerPoint slides, via the Skype for Business connection, augmented with anatomical diagrams and images which could be annotated and labelled using the interactive whiteboard function.

3.3.3. Session observations and feedback

The sessions were well received, with the main advantage voiced as the ability to revise relevant anatomy prior to their clinical rotations, as several months had elapsed since the cohorts had last studied anatomy. This was similar to those comments given by the year 2 students who appreciated revisiting anatomy materials and being taught by the anatomy staff who knew their pre-existing knowledge levels.

Some of the concepts discussed related to material that had not yet been covered by the students in their studies. This meant that having the clinical facilitator at the student site was key to the success of these sessions, so that direct questions could be asked to clarify any new concepts. There was also praise for the anatomical expertise of the staff as an asset for this mode of teaching. Whilst these sessions were not undertaken as part of a definitive quantitatively analysed study, by using the qualitative comments we can see that these sessions were felt to be useful in promoting anatomy in the later years of study, and in improving the integration of basic sciences at all levels of the curriculum.

4. Discussion

Overall the teaching sessions delivered within the University of Bristol Medical School Surface Hub pilot were well received. Our case studies linking anatomy and clinical teaching sessions received positive feedback and worked well for both students and teachers.

4.1. Advantages

There were multiple benefits from running the sessions in this way, and both the design of the session and the technology itself encouraged a collaborative approach to learning.

This was one of the first times real-time anatomy teaching delivery had been made possible during remote student clinical placements. Using these sessions, we can reinforce the importance of the anatomical knowledge underpinning clinical practice and build on the learning achieved in the centralised teaching earlier in their course. Thus, these sessions extend the anatomy teaching vertically into the clinical training, which is highly desirable in an integrated curriculum [24]. Student feedback showed they appreciated this teaching, which matches opinions found at other institutions where anatomy teaching sessions have been implemented within clinical attachments [42,43].

Using videoconferencing via the Skype for Business tool, we were able to deliver anatomy teaching at the time of clinical experience, as synchronised distance learning. Other institutions have also seen success of implementing two-way conferencing to deliver synchronous distance learning in medical education, although not specifically for anatomy [44].

Next, there is the ease of use of this device. The Surface Hub runs Microsoft Office 365 and links easily with IT systems at both the university and hospitals and can be connected either wired or wirelessly to the internet. PowerPoint, Word and Excel files can be developed separately and can then be loaded on the Surface Hub, ready for teaching sessions. This familiar software allows materials to be easily reviewed and sent out to students as a learning resource/revision aid, either by attachment to email, or upload to an online document store such as Blackboard, SharePoint or Google Drive for example.

The interactive digital whiteboard function is extremely intuitive, and multiple individuals can draw on this at the same time, increasing the collaborative nature of its use. The tutors at the remote site can view what is being drawn in real-time and offer verbal or written feedback and can also share their screen with the opposite site to add to the information (boardcasting). Other institutions have used similar techniques by broadcasting the image of a static whiteboard across an internet signal during distance learning teaching [44]. Whilst this has a similar effect, the benefit of the Surface Hub is the sharing of the *same* screen which allows annotations at both sites.

In terms of the teaching design, in Case Study 1, the Surface Hub enabled a direct link to be established between basic science knowledge, a real patient and pathology. Students felt it beneficial to have "experts" in both clinical and basic science present at the same time in the same session without the need for physically travelling. Similarly, this provided a method to allow real patients to be involved in anatomy teaching without needing to travel away from the hospital to take part.

4.2. Disadvantages

It is important to highlight that whilst we consider these sessions successful in delivering anatomy expertise to students at the clinical academy regional medical campuses at Bristol, not everything worked seamlessly. Whilst the functionality of the Surface Hub for making annotations to the same screen worked well, to further increase the collaborative working, we found it would have been useful to be able for the interactive whiteboard to be editable simultaneously at each end. At the time we resolved this by running a duplicate version of the PowerPoint workbook at the anatomy end that we screen-shared with the hospital in the event we needed to correct any errors or demonstrate a principle. We are pleased to report that simultaneous whiteboard editing functionality has since been added to the Surface Hub's system, and it is now possible to edit the interactive whiteboard from multiple sites at the same time. It should be noted however, that in using this multidirectional editing feature, the drawback could be that this could lead to duplication and therefore confusion. This would be particularly evident if more than two Surface Hubs were to be linked.

Most of the time the connectivity of the system using the internet was very good, and one of the key advantages of the Surface Hub. However, as with all technology linked learning any internet connectivity problems can cause an issue, and teachers must be prepared for this within the set-up of a session. We utilised the University wireless internet at the CAA, which had few issues, whereas the NHS hospital sites at the Clinical Academies had more challenges with wireless connectivity. This could potentially be due to high firewall restrictions found at clinical hospital locations. The issues with the wireless provision at one site were such that it prohibited a second hospital site from joining the teaching session in case study 1. This highlights the need for excellent internet provision when using devices such as the Surface Hub to implement synchronous distance education, and that even with good technical support (as was available during the pilot), technical issues can still prove disruptive to teaching [29].

Due to restrictions and regulations surrounding the Human Tissue

Act (HT Act) and the display of human tissues for anatomical examination and teaching, we were cautious about real tissue use in the teaching sessions during the pilot. It was felt that it was difficult to guarantee the audience at the NHS hospital sites, and thus this had potential for unpredicted sharing of images. Also, whilst the connection available to us during the pilot was via an encrypted Skype for Business call, it did not have a higher-level end-to-end encryption desirable for sending real tissue images to enable such a session. The Human Tissue Authority (HTA) in the code of practice C: Anatomical Examination stipulates that whilst the making and displaying of images falls outside of the scope of the HT Act, practices must be in place to ensure the dignity of deceased people at all times, and that there are systems in place to prevent the inappropriate use of images [45]. Working with the CAA Designated Individual (DI) and taking appropriate advice, we decided not to use real human tissue in these broadcasted sessions, instead utilising models, diagrams and drawings as appropriate.

It must also be acknowledged that whilst the Surface Hub teaching is able to link the anatomy expert staff to the clinical teaching sessions, it is not able to deliver the same 3D experiences that are possible when the students are on site at the anatomy facilities. These sessions offer a largely 2D experience, although 3D reconstructed images can be used, displayed and manipulated on the screen. This is not the true haptic sensory experience of the dissection room nor the virtual immersive environment seen using VR technologies [46,47].

Despite these perceived disadvantages from the tutors, the students remained very positive about the sessions and no negative feedback was received.

5. Limitations

Whilst we have received positive feedback from the sessions, we acknowledge that we have only trialled a couple of different sessions during our pilot. It is thus difficult to generalise these findings. We have also only collected qualitative comments rather than formalised quantitative feedback on the performance of the sessions, which does not allow for data-based analysis of the impact of the sessions. We had also hoped to trial connecting between more than one Clinical Academy with CAA, but unfortunately internet connection issues and timing did not allow this to take place during the timeframe of the pilot. Due to the small number of students involved we cannot yet measure the impact of these teaching sessions, although this may be possible if such sessions were implemented across the medical programme for all students.

As the pilot was undertaken during curriculum development, we do not yet have data from sessions run during the main programme. Future work will be required to trial this as the MB21 curriculum review process moves forward. We believe that face-to-face teaching of anatomy using real human tissue continues to be the gold standard for our centre. We decided not to broadcast cadaveric material during the pilot, and until we can secure an internet connection with a higher level of encryption, we will be reviewing these Surface Hub sessions alongside other methods for delivery of synchronous distance anatomy teaching to higher years medical students.

6. Conclusion and future

Integration of a vertical anatomy curriculum within a medical programme remains challenging. The number of students and the requirement for clinical placements across a wide geographical area make the delivery of high-quality anatomy training during the later years of the programme particularly difficult. By embracing technology and acknowledging the challenges, we have found a way of bringing together the anatomy and clinical settings in real-time teaching sessions using the Surface Hub. This simple to use, effective and interactive device, allows anatomy to take a firmer position within the tutorial teaching delivered during clinical placements, and thus within the medical curriculum as a whole.

The curriculum review continues to move forward at Bristol Medical School, and we hope to be able to run teaching sessions based on our pilot during years 3–5 of 'MB21' starting in academic year 2019–20. Once we have developed and refined such sessions, we will be able to consider a wider research study of student anatomical knowledge and investigate the impact of using this technology to promote anatomy learning for medical students on clinical placements.

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Ethical review

No formal ethics approval was required from the University of Bristol for this study, but adherence to good ethical principles were considered throughout the work.

Declaration of competing interest

None.

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