Modernising Anatomy Teaching: Which Resources Do Students Rely On?

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ABSTRACT: The way in which we learn anatomy has changed exponentially over the decades and students now have access to lecture notes, textbooks, computer-assisted programmes, and a wide variety of internet based information. This study explored which resources were the most (and least) useful for a group of first year, undergraduate, medical students, with minimal prior content exposure (aged 18 and 19 years old, n = 76), over an 18 month period. Anatomy websites were found to be the most useful (30%), followed by tutorials (20%) and lectures (19%). A total of 13% found the university computer-assisted learning (CAL) platform least useful. We subsequently enhanced our ‘urogenital’ CAL anatomy module, with inclusion of new and updated images, videos and tutorials, as well as, digital and printed 3D-models. A post-intervention survey (n = 81) showed an increase from 12% to 27% for CAL as being most useful, and a decrease from 13% to 3% as being least useful. Our results provided a snapshot of students’ preferences in studying anatomy, and highlighted the importance of digital platforms and the need for evaluating our own learning resources. We must be mindful that there is an increasing tendency for students to rely on the Internet for information, which may expose them to unfiltered and unreliable content. We conclude that educators must be aware of the spectrum of learning resources used by students, to ensure that our own Institutional eLearning platforms are optimised to meet the diverse needs of learners.

KEYWORDS: Anatomy, teaching, computer assisted learning, urogenital, 3D-models

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Introduction

For centuries, the primary tools for teaching anatomy have been lectures, tutorials, textbooks, cadaveric dissections and demonstrations from prosected specimens.\(^1\)\(^-\)\(^3\) In the early 1980s, McMaster University in Canada and the General Medical Council (GMC), championed a reform to our medical curriculum, moving away from the traditional didactic forms of teaching and passive learning, into a more proactive and interactive format, which included problem-based learning (PBL), early clinical exposure, as well as, computer-assisted learning (CAL).\(^2\)\(^,\)\(^4\)\(^,\)\(^5\)

In the past decade, as digital technology advanced, the use of CAL has increased exponentially, with multiple studies demonstrating its benefits, including significant improvement of spatial abilities amongst medical students.\(^6\)\(^,\)\(^8\) Furthermore, in present times, the internet has become a major platform for resources, with one study showing, 97.4% of medical students used the internet as one of their sources for information.\(^9\) Thus, it is essential for us, as educators, to be aware of the different resources available to students and tailor our teaching towards their preferential way of learning.

At the University of Oxford, the teaching of gross anatomy retains a more classical approach, through lectures, tutorials, and demonstrations from prosected cadaveric specimens. We recognise that more students are accessing online learning tools. At present not enough evidence is available to indicate which educational resources medical students prefer to use and are common amongst Pre–Clinical medical students. Recent publications have mentioned that research carried out to investigate the impact of CAL and its incorporation, along with conventional teaching methods, may improve learning through simulations, interactive collaboration, and feedback.\(^9\)

We undertook an 18-month project to survey the types of learning resources that our students used, and to implement improvements in our delivery of anatomy teaching.

Description

Survey – What resources do student rely on?

An online survey was created and distributed to all first year medical students (n = 140) at the University of Oxford, at the end of the academic year, 76 students responded (54%). All students included in the survey had successfully completed the Year 1 anatomy syllabus and assessments, which included: musculoskeletal, cardiothoracic and respiratory, abdominal and urogenital systems. The survey contained three questions:

1. Which resource do you find most useful when learning anatomy? Agree or disagree.
2. Which resource do you find least useful when learning anatomy? Select one option.
3. Dissection is the single most useful resource in learning anatomy? Agree or disagree.

For questions 1 and 2, the options were:

- Internal resources: ‘CAL material’, ‘lecture notes’, and ‘tutorials’ (interactive small group teaching)
External resources: ‘Textbooks’, ‘anatomy websites’, ‘YouTube videos’, and ‘other medical school’s online material’

‘Anatomy dissections and demonstrations’ was excluded as an option, as this domain may exclusively dominate as the most useful resource for all students. Question 3 aimed to clarify and confirm this confounding factor.

Which resource do you find most useful when learning anatomy?

‘Anatomy websites’ were most popular (30%) (Figure 1 and Table 1). This was followed by: ‘tutorials’ (20%), ‘lecture notes’ (19%), ‘textbooks’ (13%), ‘CAL’ (12%), ‘YouTube videos’ (5%) and ‘other medical school’s online resources’ (1%) (Figure 1 and Table 1). Overall, 51% of students found one of the internal resources most useful, comparatively, 49% found one of the external resources most useful (Figure 2).

Which resource do you find least useful when learning anatomy?

Students found that ‘lectures’ were the least useful with 22%, followed by: ‘textbooks’ (18%), ‘other medical school’s resources’ (16%), ‘CAL’ (13%), ‘tutorials’ (13%), ‘YouTube videos’ (11%) and ‘anatomy websites’ (7%) (Figure 4 and Table 1). Overall, 48% students found one of the internal resources least useful, and 51% found one of the external resources as least useful (Figure 5).

Dissection is the single most useful resource in learning anatomy? All students agreed that dissection is the single most useful resource in learning anatomy (Table 2).

Key outcomes

This survey highlighted that digital platforms play a critical role in the learning of anatomy, with ‘anatomy websites’ being most popular, and just under half of the students, voted one of the digital platforms as the most useful. More students disliked lecture notes and textbooks, this shows this cohort of students preferred an active and interactive way of learning which was self-directed using computer assisted resources. The University’s internal digital platform, CAL, was less popular; with 13% stating it was least useful. Thus, we decided to enhance our CAL platform, in particular, Urogenital anatomy, as an initial intervention.

Intervention – Enhancing urogenital anatomy teaching (CAL and 3D models)

The CAL module for urogenital anatomy was selected for intervention. The urogenital anatomy had often been challenging to teach and learn, and often difficult to depict in 2D images and even in cadaveric demonstration, owing to its deep anatomical location. Thus, this was an ideal anatomical region to enhance our learning resources.
A working group comprising third and fourth year medical students, the Director of Anatomy, the Emeritus Professor of Anatomy, and the Director of Pre-clinical studies, analysed the existing syllabus and devised a set of clear objectives to be met by the new module.

The computer-assisted learning (CAL) material was screened; outdated images and videos were removed, and replaced by new ‘copyright free’ images and videos. One of the key changes was the use of a computer-software named ‘Moodle’, which allowed the visualisation of anatomy in 3D for the students, as well as the capabilities to create and print a tailored 3D model of a particular anatomical region. For the urogenital CAL module, we used this software to educate the students of the key anatomical structures, and subsequently a 3D model was printed to further reinforce the anatomy (Figure 6).

Post-intervention survey

The new CAL module was introduced to the initial cohort of 76 students. All found the new module to be significantly better and would consider this resource as one of the most useful.
We introduced this new module to a new group of first year medical students. 81 students (81/140 – 58%) responded to the survey. We asked the same two questions as per the first survey (questions 1 and 2, as above) with the same answer options.

The most useful resource remained ‘anatomy websites’ with 28%, followed by our ‘new CAL’ with 27%, then by ‘tutorials’ (20%), ‘lecture notes’ (13%), ‘textbooks’ (6%), ‘YouTube’ (5%) and ‘other medical schools’ online material’ (1%). We found a significant improvement ($P = .005$, Chi-square test) of students finding our new CAL module as the most useful (27%), compared to the original CAL module (12%) (Table 3).

The least useful resource was ‘textbooks’ (25%), followed by ‘lecture notes’ (24%), ‘other medical school’s online material’ (17%), ‘tutorials’ (13%), ‘YouTube’ (11%), ‘anatomy websites’ (7%) and ‘new CAL’ (3%). In terms of comparing the new and original CAL, there was a statistically significant reduction in students regarding CAL as the least useful from 13% to 3% ($P = .01$, Chi-square test) (Table 3).

Discussion

Which resources do students favour?

Students use a range of learning resources to attain their anatomy knowledge, ranging from notes and books to the Internet, and their choice depends upon their personal preference and

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**Table 2.** A table showing the percentage of students that agreed that dissection is the single most useful resource in learning anatomy.

| Yes     | 100% |
|---------|------|
| No      | 0%   |

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**Figure 4.** A graph showing the different types of learning resources as voted by students as least useful.

**Figure 5.** A pie chart showing the distribution between internal and external resources as voted least useful for learning anatomy.
experience, the quality and availability of the resources, the tutors recommendations, and lastly, the curriculum and style of teaching.

Traditionally, cadaveric specimens, textbooks and tutorials had been considered the best forms of learning anatomy, but there has been an emergence of the use digital and online resources. This effect can be shown in our first survey, where ‘anatomy websites’ were considered by most students (30%) as the most useful resource and 48% of students found at least one of the digital resources (eg, CAL, YouTube) as the most useful. We did not formally record which ‘anatomy websites’ students were utilising in this context. Surprisingly, ‘lecture notes’ and ‘textbooks’ were considered by most students to be the least useful resources for anatomy. Although, one must interpret this data in caution, as the preferences were distributed evenly across the board, which highlighted the fact that students’ preferences can vary tremendously. Unsurprisingly, all students agreed that ‘dissection’ was the most useful resource for learning anatomy, which is accordance with other studies that had analysed the usefulness of cadaveric teaching. This is one of the reasons that cadaveric dissection remains at the forefront of our teaching methods at the University of Oxford.

| CAL           | PRE-INTERVENTION | POST-INTERVENTION | OUTCOME          | P VALUE |
|---------------|------------------|-------------------|------------------|---------|
| Most useful   | 12%              | 27%               | Increase (+15%)  | .005    |
| Least useful  | 13%              | 3%                | Reduction (−10%) | .01     |

Table 3. A table showing the changes in perception of the new CAL module, in terms of the most and least useful resource for learning anatomy.
Computer-assisted learning can come in different forms, including internal CAL modules, designed and provided by the university, to external digital platforms that can be subscribed to or accessed on the Internet. Digital platforms on anatomy could range from video tutorials or lectures, to beautifully illustrated 3D images of computerised or dissected cadaveric anatomy.

Studies had shown that the supplementation of CAL with traditional teaching, compared to traditional teaching alone, had improved students’ ability to retain anatomy. Another study demonstrated the benefit of CAL in improving students’ perception of learning anatomy, and consequently examination performance. In a literature review, eight studies were identified examining the use of CAL for undergraduate medical students in anatomy teaching, all favourably supported its use, but there was insufficient evidence to show that CAL could replace traditional styles of teaching exclusively. Interestingly, but not surprisingly, a study in 1990 failed to show a significant benefit of computer-assisted lessons in teaching anatomy, when compared to traditional styles; this may be due to the deficiencies of the technology three decades ago. This study, in fact, further assists us in predicting that, as technology advances, CAL’s position as a leading source for learning will grow, and may eventually supersede more traditional styles as the leading learning resource for students.

In terms of analysing our own learning resources, our initial survey showed that only 12% considered our internal CAL modules as most useful, and 13% found it least useful. The transformation of the CAL module on the urogenital anatomy included new tutorials and videos, and 3D digital images, showed significant improvement of students’ perception, which showed significant increase in students finding the new CAL module as most useful and less students considering it as least useful. This outcome highlighted the importance of continuous evaluation and modulation of university resources, but also demonstrated the impact of how newer technologies were required to enhance their learning perception.

Furthermore, ‘anatomy websites’ and ‘YouTube videos’ were considered as one of the most useful resources. This can be backed up by studies that had shown ‘YouTube’ was used by 78% of students as their primary source of anatomy learning. Overall, the adaptability and efficiency of the Internet has transformed students’ approach to self-directed learning.

Interestingly, a study showed that students that are more proactive in seeking online resources were likely to be more self-directed and self-regulatory, which by their own nature, would be more knowledgeable and passionate about anatomy, thus questioning the true benefit of online resources.

Digital and printed 3D-anatomy models

The role of 3-dimensional (3D) digital and printed models in the teaching of anatomy has grown in recent years. A study was conducted by comparing 2D and 3D digital images in the learning of the surgical anatomy of the liver; results demonstrated a significantly higher student satisfaction and learning efficiency for the

Figure 7. Augmented reality using the HoloLens™ device deployed at the Case Western Reserve University, providing students the opportunity to visualise anatomical structures outside of the dissection room; courtesy to the Interactive Commons at Case Western Reserve University.
already adopted or trialled these modalities with good results.27-29 Never-the-less, we look forward to taking the principles we have learnt here, and applying them to future CAL modules, including the: musculoskeletal, respiratory, gastrointestinal, nervous, and cardiovascular systems.

Limitations
The limitations of this study relate to its retrospective and single centre design. In addition it primarily presents subjective opinion as collected through a non-compulsory, anonymous, questionnaire, which did not collect any demographic data. As a result, it is impossible to exclude the possibility of a sub-cohort of opinion being omitted, simply because those participants would have been less likely to engage and complete the questionnaire. It does not control for the infinite combinations of prior material exposure that participants may have used in the past. This study did not record any objective outcomes, such as exam performance, for example. This would be a useful measure of student performance to correlate with their resources of choice.

Conclusion
In conclusion, students of anatomy will rely on different learning resources and it is essential, as educators, to ensure that all available resources are optimised wherever possible. The use of digital and online resources is increasing, and has already greatly benefited students in their self-directed learning. The traditional sources of anatomy knowledge, such as lecture notes or textbooks, are slowly becoming an equivocal resource for students. It is vital for educational establishment to invest in enhancing their digital platforms, including 3D images and displays, 3D printed models, as well as augmented or virtual reality software. Finally, we must be mindful that, although, the surplus of online resources may benefit students, learning resources must be filtered and screened carefully. Thus, this reinforces the need for educators to ensure that their digital platforms are optimised and relevant to our new-breed of technophilic students. Continuous quality assessment of one’s own internal resources by ongoing student surveys can be helpful. The gold standard of anatomy learning remains cadaveric dissection but can be positively reinforced by novel digital resources.

Author Contributions
All authors contributed to the design and implementation of the study. All authors discussed the results and contributed to the final manuscript. MW and CH designed the questionnaire and collected the data. BL wrote the manuscript with support and reviews from MW, CH and TC. Project supervised by TC.

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