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Anatomy Practical Session Using a Virtual Three-Dimensional Anatomy Application During the COVID-19 Pandemic

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ABSTRACT

COVID-19 caused interruptions to the anatomy curricula in medical schools worldwide. During the pandemic, the Anatomy Department of the School of Medical Sciences at Universiti Sains Malaysia (USM) conducted online anatomy practical sessions using two-dimensional atlas images and pre-recorded demonstration videos, which were shown live during synchronous learning or embedded into our learning management system for students to learn asynchronously. Some lecturers experienced logistical and technical difficulties during the online practical sessions, which necessitated rescheduling. Given the limited online resources, the School of Medical Sciences, USM purchased the Complete Anatomy application (3D4Medical, Ireland)—a 3D anatomy atlas application—to increase the effectiveness of the online practical session. This article presents the basic features and benefits of using the Complete Anatomy application for practical sessions. We further share our insights regarding the use of virtual technology in teaching so that other institutions may learn from our experiences.

Keywords: *Three-dimensional technology, Anatomy application, Teaching and learning, Anatomy practical, Pandemic*

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INTRODUCTION

On 11 March 2020, the World Health Organization (WHO) proclaimed COVID-19 to be a pandemic (1). The educational systems in many countries across the world were severely impacted, and efforts to restrict COVID-19 transmission led to the unscheduled closure of schools and universities in over 100 nations. More than one billion students were affected as a consequence of these school and university closures (2–3). The anatomy curricula in medical schools

were also affected and even temporarily halted, while other academic institutions developed contingency measures for online learning (4). Despite the general success of online teaching, many anatomy lecturers faced difficulties when designing and delivering online learning materials (3, 5–8). Moreover, many anatomists raised concern about the inadequate development of psychomotor skills when anatomy practical sessions were conducted online (9–10). Lecturers further highlighted the lack of hands-on activities, limited access to cadaveric specimens and anatomy models, and limited peer interaction during online anatomy practical sessions as being among the drawbacks of online anatomy practical sessions (6, 11).

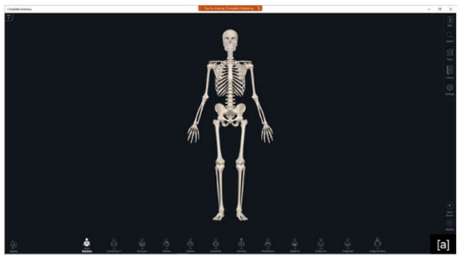
The faculty at the Department of Anatomy, School of Medical Sciences, Universiti Sains Malaysia (USM), faced similar challenges when conducting online practical sessions. During the early phase of the pandemic, the students had no opportunities to learn using cadaveric specimens and anatomy models, as they were only provided with two-dimensional (2D) anatomy diagrams and demonstration videos via online platforms. The majority of the anatomy lecturers concluded that the online practical sessions were less effective than the routine in-person practical sessions using cadaveric specimens and other teaching tools (6). To solve this problem, the School of Medical Sciences, USM, purchased the Complete Anatomy application (3D4Medical, Ireland), which is a 3D anatomy atlas application that aims to increase the effectiveness of online practical sessions. This article presents the basic features and benefits of using the Complete Anatomy application for practical sessions. We further share our insights regarding the use of virtual technology in teaching so that other institutions may learn from our experiences.

COMPLETING ONLINE PRACTICAL SESSIONS USING THE COMPLETE ANATOMY APPLICATION

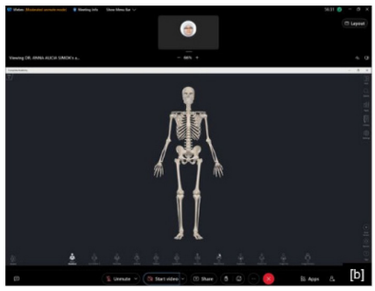
Prior to the pandemic, practical sessions at the School of Medical Sciences, USM, usually began with a short demonstration by the lecturer, followed by an objective structured practical examination-based interactive session. During the interactive session, students were given time to explore each anatomical model, cadaveric specimen or histological slide and were allowed to discuss their findings with their peers or refer to their textbooks. During the early stage of the pandemic period, all practical sessions were conducted online via teleconferencing applications, namely, Webex and Microsoft Teams, and lecturers used 2D atlas images and pre-recorded demonstration videos. These images were either shown live during the sessions (synchronous learning) or embedded into our learning management system for students to learn in their free time (asynchronous learning). The lecturers and students had limited access to cadaveric specimens and anatomical models throughout the pandemic movement control order that was enforced by the Malaysian government. The lecturers were thus compelled to be innovative when creating instructional videos for the practical teaching of anatomy with limited resources and capacity. This situation imposed significant teaching and psychological burdens on the lecturers and could have indirectly influenced the quality of the online anatomy laboratory sessions (6, 12–13).

Given the limited online resources available for anatomy teaching and learning (T&L) during the pandemic, the School of Medical Sciences purchased the Complete

Anatomy application, which is a cloud-based educational application that allows users, both lecturers and students, to explore the human body in intricate 3D detail. It is easily downloadable on personal computers and Android mobile devices via the Google Play Store. The School of Medical Sciences purchased a three-year subscription, which includes 20 educator licences and 600 student licences. An annual subscription is necessary for student and professional licences at USD44.99 and USD119.99, respectively, at the time. Prior to the procurement, the students and lecturers were given access to the free trial version of Complete Anatomy application,, which has limited features, for two months to familiarise themselves with the application. During an anatomy practical session using the Complete Anatomy application, the lecturers and medical students would log into the Webex teleconferencing application for live practical sessions. The lecturer would then share their interface of the Complete Anatomy application with all the students (Figures 1[a] and [b]).



(a)



(b)

Figure 1: [a] A lecturer's view of the Complete Anatomy application is shared on Webex; [b] A student's view of the Complete Anatomy application is shared on Webex.

During the demonstration, the students would utilise a second device, either their tablets or mobile devices, to access the Complete Anatomy application and self-explore the content in line with the lecturer's instructions. In the application, all the regions of the human body, from the head to the feet, can be displayed, and anatomical images of both male and female models are available, which is useful when teaching the reproductive system. Each model can be rotated upwards, downwards, and sidewards to mimic an actual model that can be rotated in a student's hands. These models can further be magnified or moved around to allow better viewing of the structures.

The use of the Complete Anatomy application in the online anatomy practical sessions at USM was accepted well by the lecturers and students. Based on the continuous online feedback gathered from the students and lecturers at the end of each semester, the Complete Anatomy application was perceived as a user-friendly tool that facilitated the T&L process during the online anatomy practical sessions that took place throughout the pandemic. Both the students and lecturers used the application at least once a week, although the majority of them used the application daily for the practical sessions, self-study, group discussions, problem-based learning sessions and bedside teaching. The Complete Anatomy application feature most frequently used by the lecturers and students was the labelling or annotation of the anatomical structures, which was beneficial during the practical sessions as the students were required to identify the anatomical structures and describe them during group discussions. During group discussions, diagrams can be displayed in 3D to allow students to navigate various views of the models. The labels or annotations that contain the descriptions of the anatomical structures can be make explicit by clicking on the parts of the structures of interest (Figure 2). This task

facilitates the learning process as students and lecturers do not need to manually type out the labels for each pointed structure during practical sessions.

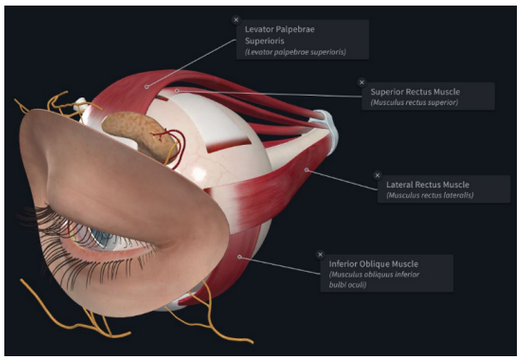


Figure 2: The label function on the 3D model of the eye using the Complete Anatomy application.

In addition to the annotations feature, the "hide" and "isolate" options were the second most frequently used features by the lecturers and students. These features allow lecturers to perform dissection-like techniques during online practical sessions. For instance, when teaching about the perineum region in a practical session, the most superficial layer, the skin, to the deepest layer, the deep perineal pouch and its related structures, can be shown one at a time. For instance, a lecturer can select the skin (Figure 3[a]) and click the hide button to remove the skin layer, thus revealing the second layer of the perineum (Figure 3[b]). The user can also choose the "multi selection" feature to simultaneously select and conceal any undesired elements using the "hide" function. This feature is beneficial if a lecturer needs to speed up the dissection-like demonstration. If the lecturer does not intend to hide an element, they can isolate it by simply selecting the desired part (Figure 3[c]) and then clicking "isolate". The selected structure will then immediately be shown, and the other structures will be hidden (Figure 3[d]). The "multi selection" function can also be applied to the "isolate" function. Another notable feature of the Complete Anatomy application is the "layer" function.

Many additional layers, including those for arteries and veins, lymphatic vessels and connective, muscular, neurological, respiratory, digestive, endocrine, urogenital and integumentary tissues, are provided in the application. This function may appear similar to the aforementioned functions; however, it is quite different. Each layer may consist of a single structure or a few collective structures that are grouped according to specific systems. For example, to teach students about the brachial plexus, a lecturer needs to select the upper limb model to reveal the skeleton (Figure 4[a]). Nerves and muscles could be added to the 3D skeleton model by clicking on the "+ nervous" and "+ muscular" icons, respectively (Figures 4[b] and [c]). To demonstrate the course of the brachial plexus and its branches in relation to the musculature, the muscle layer is added to the 3D model (Figure 4[c]). During the pandemic, the lecturers employed this feature frequently, especially when demonstrating a particular anatomical location's nerves, arteries and blood supply (Figure 4[d]).

The most advanced feature of the Complete Anatomy application is the augmented reality (AR) function, which allows users to view anatomy models in AR mode (Figure 5). This function may not be relevant for online classes, but it may be helpful for face-to-face small group discussions and students' independent studies. Despite the pandemic, a few students at our medical school commented that studying anatomy using the AR function was engaging and made learning enjoyable. A few studies have found that incorporating AR into teaching content or using AR learning apps increases students' enthusiasm to learn (14–15).

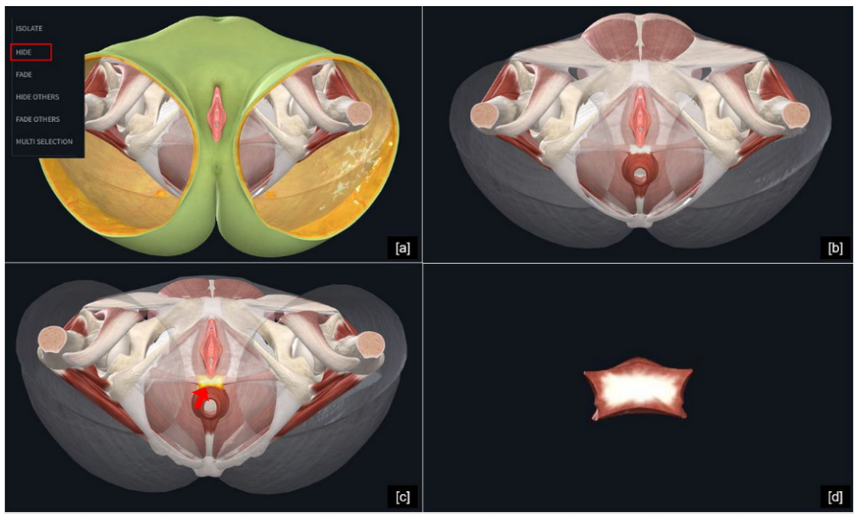


Figure 3: [a] A screenshot from the Complete Anatomy application showing the 3D perineum model with the skin layer highlighted in green. The upper left corner shows the hide button; [b] The 3D perineum with the skin layer removed to expose the fascia layer; [c] Red arrow : The perineal body selected; [d] The perineal body structure after isolation.

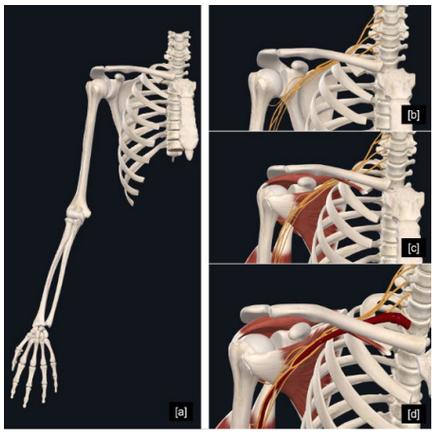


Figure 4: [a] A screenshot from the Complete Anatomy application showing the 3D upper limb model with only the skeleton; [b] The 3D upper limb with the brachial plexus added; [c] The 3D brachial plexus–upper limb model with the muscle layer added; [d] The 3D model shows the arteries of the upper limb.

In addition to the aforementioned features, the Complete Anatomy application platform offers videos and courses. Demonstrations of joint movements are aided by videos showing limb movements. Individuals from various universities have also developed and shared brief lecture videos. The lecturers utilised this function to generate short lecture videos for use in practical and lecture sessions. The lecturers were required to first attend a training session conducted by a representative from 3D4Medical, and the techniques and actions involved in generating the videos subsequently became relatively simple. The training sessions were also attended by the students and will be given annually to future groups of incoming medical students.

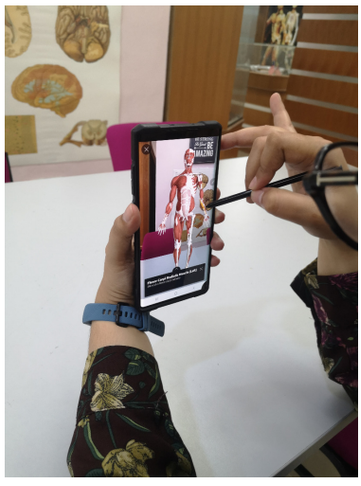


Figure 5: A student using the augmented reality mode on a smart device.

Complex body components, such as the pelvic diaphragm and perineum, can be challenging to explain using plastic or plastinated anatomy models. Indeed, Complete Anatomy application is an invaluable resource for illustrating these components. It is also advantageous when depicting small anatomical structures, such as the basal ganglia and subthalamus in 3D shapes, which may be difficult to convey or lacking in plastic models. Previous studies have shown that 3D virtual models are more effective than 2D images for teaching small anatomical structures such as the inner ear and are particularly beneficial for students with low spatial ability (16–17). In addition to its usage during practical sessions, the Complete Anatomy application allows students to learn flexibly. Students can explore all the models in their own time and place as frequently as needed. This flexibility allows them to spend more time with the materials and to learn more as it increases their intrinsic motivation and reduces their cognitive load (14). In a comparative study using a virtual microscope, the authors indicated that having the freedom to study at a student's preferred location, pace and time with an easily accessible learning tool reduced students' anxiety and stress levels, which is a domain of intrinsic motivation in learning histology (18).

We have yet to utilise the numerous additional capabilities of the Complete Anatomy application, such as the course and student assignment features. The course feature allows instructors to construct brief courses on any topic, complete with short videos and student assessments. Despite its lack of formal use in classes, students who have tried the feature have commented that the course function was helpful for exam preparation. Notwithstanding, the Complete Anatomy application still has room for improvement. Based on lecturers and students' feedback, some structures in certain model sections, such as the habenular trigone of the epithalamus, the splenic vessels and the medial-lateral geniculate bodies of the thalamus, cannot be satisfactorily visualised. Furthermore, students have commented on their experience of "computer sickness", which reflects the perceptual disturbances felt when navigating the models' sidewards, upwards and downwards rotations, as well as when minimising and maximising the size of the anatomical models. It has been argued that visual motion can induce motion sickness, and the condition is referred to as visually induced motion sickness (VIMS). Approaches to reducing virtual reality sickness (i.e., additional sensory information) should be considered when using the Complete Anatomy application for teaching (19–21).

CONCLUSION

If there is one contribution the COVID-19 pandemic has made to humankind, it is to be grateful for what it has. The Department of Anatomy, School of Medical Sciences, USM, has successfully conducted anatomy practical sessions using the Complete Anatomy application during the COVID-19 pandemic without any major problems. The COVID-19 pandemic has provided an opportunity to explore and learn new approaches to T&L anatomy that can benefit students. Indeed, incorporating this virtual 3D technology-enhanced T&L tool aligns with the USM's agenda of ensuring the Sustainable Development Goal 4 of the United Nations pertaining to learning is met (20–23). We will continue to explore the numerous other features provided by the Complete Anatomy application and possibly research other virtual 3D technology teaching modalities to supplement and improve the T&L experience for students at the School of Medical Sciences, USM.

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