Designing Online Anatomy Education by the 'Debug' Guideline: COVID-19 Lessons Learnt

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Abstract

Within the field of medical education, anatomy education is a specific and demanding place for teaching the subject entirely online for medical students, not just the lectures, but also comprehensively providing input and assessment in an engaging and learner-centred approach. A step-by-step guideline called Debug has been developed to assist anatomy educators in positively designing online anatomy learning. The acronym Debug encourages educators to consider D - Design online anatomy learning as an overarching theme that initiates the process of developing online anatomy learning through pedagogically informed decisions. The acronym e stands for the educational principle of cognitive load theory-based lecture model (CLT-BLM), adherence, which has been documented to be valid in designing anatomy lectures. The acronym, b- blending online teaching as it guides educators to consider scaffolding learning online anatomy education with diverse resources. Elements of active learning and higher-order thinking can be accomplished by considering different online evaluation tools and resources that flavoured the learning outcome with the essence of formative evaluation and feedback. Acronym u stands for Using Online Formative Assessments (OFAs), which has strong evidence supporting medical education. Followed by acronym g, for gaining continuous improvement, which guides educators to consider online anatomy learning with appropriate online evaluation strategies. In addition, gaining ground on student well-being, the most important milestone is that a positive online learning environment should be cultivated in any form of learning. The Newcastle University Medicine Malaysia (NUMed) Anatomy Working Group (AWG) has designed a case study using the practical tips following the Debug guideline.

Keywords: Anatomy education; Pandemic; COVID-19; Online-learning
Introduction

If history repeats itself, should we learn from it? The pandemic COVID-19 has challenged the anatomy education landscape as we know it and will undoubtedly have a ripple effect on common practices and policies moving forward. Fundamentally, educational institutions need to consider the challenges brought about by the current crisis and also look at how a new normal may change foundational elements of anatomy learning. Technology-enhanced learning (TEL) has been at the heart of our understanding since the outbreak of COVID-19, and the investigation of TEL is a continuing concern in the field of medical education. The COVID pandemic has truly tested TEL potential in medical education and has imposed a great challenge for educators across the globe. TEL is an increasingly important area in medical education, and studies on TEL represent a growing field in medical education and an increasingly important area in the effort to embrace 21st-Century learners. As noted, 'when technology drives e-learning rather than the learner and the learning, and when it uses designs and approaches that were not originally built for e-learning, then often technology does not enhance the learning' (Dror et al., 2011).

Thus, the mindful groundwork of technology use during the pandemic period is crucial (Veasuvalingam and Goodson, 2020), therefore planning to create a positive online platform (Evans et al., 2020) demands several strategies (Ozer et al., 2017; Guy et al., 2018). Although, e-learning has been well integrated within the medical education mainstream (Ellaway and Masters, 2008), leaning entirely online without face to face interaction can be stressful (Gillett-Swan, 2017). Web-based learning, role play, video vignettes, and mannequin-based simulated patients minimise the disruptions to medical education (Lim et al., 2009). COVID-19 has sparked interest in TEL research and, like a meteorite, has created a crater of new knowledge disseminated for better application and future proof the online learning terrain to medical education, in the event this to recur. Thus, the recent COVID-19 educational technology research has provided an abundance of new knowledge that can be adhered to in the future application of online learning. The subsequent discussion is based on careful planning and preparation to be considered in designing online anatomy education in a systematic approach.

Learning Design

Anatomy is widely considered to be the foundation of medical sciences, but it is often viewed as an on-going and demanding topic of medical education. The higher education ecosystem has historically been slow to adapt. But educators, faced with unprecedented urgency, now can deliver high-quality teaching and learning online. Quality online teaching requires thoughtful instructional design and preparation, utilising a systematic model for design and advancement (Hodges et al., 2020). On that note, learning design has been defined as "the creative and deliberate act of devising new practices, plans of activity, resources, and tools aimed at achieving particular educational aims in a given context" (p. 86) (Mor and Craft, 2012).

The term design for leaning arose with the acknowledgement that educators are more than knowledge transmitters, which should promote students' active learning and higher order thinking ability in a meaningful way (Laurillard, 2008). Further to this, learning design should be by the subject knowledge, educational theory, technological know-how, practical experience, and guides students as stressed by Mor and Craft. Hence, learning design requires pedagogically informed decisions with a suitable selection of resources and technologies. The conventional approach to studying anatomy was mainly through dissection and didactic lectures (Sugand et al., 2010).

Interactive and engaging anatomical teaching experience is critical to fostering students' visuospatial skills, as the three-dimensional learning essence of anatomy requires a high degree of experiential learning (Evans et al., 2020). Comprehension of spatial anatomical connections is critical to assist in the learning of complex structures stated Evans. However, studies suggest that merely, viewing lecture recordings could distract learners (Reyna, 2020). The existing literature on anatomy education is extensive. It focuses mainly on TEL Anatomists have been dwelling with
computer-based educational innovations (Farrell and Rushby, 2016) with blended learning thus, overriding the face-to-face lectures with numerous pedagogical strategies (Khalil et al., 2018). Technology use in anatomy teaching has been reported to enhance students’ learning (Hallgren et al., 2002), especially cadaver digital photographs and textbook derived illustration from developing interactive anatomy images (O’Byrne et al., 2008). Further to this, multimedia learning, learning from text and pictures, are mainly reported to be of relevance (Mayer, 2018).

Designing Online Learning through Educational Principles

A crucial element of developing a favourable online learning environment will be the advancement of digital technologies based on sound educational concepts (Doherty and McKimm, 2010; Rogerson-Revell, 2015). Educators must be mindful of the higher or lower order in which the intended outcome is determined and select an appropriate online digital tool and design the learning activity around the learning outcome. First, awareness to positively alter the online environment is critical (Sandars et al., 2020). It is essential to provide students with interactive experiences, acknowledge social learning factors with teachers and peers, promote active facilitation and support learning with immediate automated input through the synchronous and asynchronous platform (Taha et al., 2020). The ability to choose effective learning resources for knowledge creation to aim at information gathering, building awareness, engaging with colleagues, communicating understanding and assessing the effect of knowledge in an impactful manner (Huang et al., 2020) is essential.

Designing by Principle of Cognitive Load Theory-based Lecture Model (CLT-bLM)

Students’ engagement improves with motivation and reduces the sense of isolation and hence enhances performance in online courses (Martin and Bolliger, 2018). It has been well established that cognitive neuroscience by cognitive load theory contributes considerably to student's engagement and active learning (Dror et al., 2011). Technology-enhanced learning (TEL) developed with cognitive neuroscience as stressed by Dror has been reported to enhance learning. To create a positive online learning experience, one should relay to curriculum design, evidence-based educational philosophies and suitable online learning strategies (Reyna, 2020; Sandars et al., 2020) mindfully. Educators need to be mindful of learning activities designed not to overload the student's cognitive capacity.

Cognitive load theory (CLT) has been proposed to regulate learning activities that minimise redundant cognitive activity (Leppink, 2017). Effective e-learning designs ought to accommodate the intrinsic load, increase the germane load, and reduce the extraneous cognitive loads (Ellaway and Masters, 2008). Conducting entirely online can be very stressful and daunting for the students. Thus, optimal cognitive loading activity is pertinent to ensure learning occurs effectively. The Cognitive Load Theory-based Lecture Model (CLT-bLM), by principles of Cognitive Load Theory (CLT) and Cognitive Theory of Multimedia Learning (CTML), has been proven to be effective in achieving optimum intrinsic load in anatomy teaching (Hadie et al., 2018). Hadie describes the model's effectiveness in enhancing the naturally, limited working memory by creating stimulating lectures to trigger the ‘attention, focus, ‘which improves the working memory with stimulating resources enabling the development of proper cognitive schema for long-term memory storage, hence better retention.

Considering, CLT-bLM into the design of online anatomy lectures, would enhance anatomy learning. Thus, lecture series of brief 5-7-minute videos engaging with attention to specific concepts, combined with mini-quiz, a case study, and live discussion has been recommended (Evans et al., 2020). Further to this, chunking virtual lectures or online instructional materials enhances knowledge retention (Méndez-Carbajo and Wolla, 2019) and facilitates the production of good schema for long term memory storage. Good schema development requires consideration of aesthetic aspects of online materials with the appropriate layout to ease vision, navigation, images, a minimal number of slides, text, colour, typography, use of images, and video principles (Reyna, 2020).
Designing Online Learning by Blending

Blending online teaching supports learning, especially when teaching is entirely online. Blended learning has been perceived very positively by medical students. Various strategies for effective implementation of blended learning has made online more learning humanistic (Margolis et al., 2017).

Blending by synchronous and asynchronous online learning mode

Various teaching methods for both synchronous and asynchronous learning (Taha et al., 2020) have been developed for integrated online learning. Taha defined the synchronous learning mode to allow students to communicate live with educators, while the asynchronous mode is used online at different times. The integrated use of all online learning modes indicates a healthy learning environment. Active learning using a variety of computer-aided multimedia resources has been shown to promote the learning process in anatomy education (Vaccarezza, 2018). Synchronous learning focusing on real-time interaction with immediate feedback can be structured along with a scheduled and live virtual classroom environment (Huang et al., 2020).

Webinars and online conferences can be a valuable resource for synchronous online learning. To promote group dialogue and improve learning with strong technical help, using a flipped-classroom approach to train for webinars (Taylor et al., 2020). Ironically, active and self-directed learning has been observed, and the role of educators can be equally assisted online in a problem-based learning session (Boelens et al., 2015). Boelens stressed that the favourable outcome was due to collaborative learning within the group. Therefore, interaction within the group discussion appears to be crucial and should be made possible when designing synchronous learning.

On the contrary, asynchronous online learning does not provide immediate feedback as expected from students (Huang et al., 2020). Described by Huang, self-regulatory learning tools, specific apps and the learning management system (LMS) are usually the platform to deliver learning content in asynchronous mode. Also, online tutorials offer students with a myriad of online multimedia educational activities (Sandars et al., 2020). Podcast was used in tandem with online PowerPoint slides as one of the asynchronous communication devices in the anatomy curriculum (Jalali et al., 2011). This study reports, podcasting short anatomical lecture reviews to be a powerful educational resource for handling students’ personal learning and encouraging students to take care of their own learning. Online discussion forums, another platform reported to be effective on student learning in the field of gross anatomy (Green et al., 2014). However, the effectiveness of this approach depends on the facilitation and feedback of the instructor (Nandi et al., 2012).

Blending by YouTube Videos as Learning Activity

YouTube videos have been reported to provide a multitude of learning benefits, such as support for multimedia learning, emphasis on attention, enhancement of the learning process, support for deep learning, better memory (Buzzetto-More, 2014; Buzzetto-More, 2015) and critical thinking (Logan, 2012). On this note, the clear orientation of video content, the integration of interactive elements for active learning, the alignment of learning outcomes, the integration of PowerPoint slides, the ideal video length recommended (Taha et al., 2020). More importantly, educational videos appeal to visual learners in support of the Cognitive Theory of Multimedia Learning (Eick and King Jr, 2012).

Medical students have successfully learned anatomical subjects with the help of YouTube (Mustafa et al., 2020). The author noted that students were very optimistic about using YouTube videos as they enhance understanding, memorisation, and retention of factual anatomical knowledge. He urged educators to focus on YouTube as one of the learning resources that suit the new ‘Z generation’ (Border et al., 2019). Also, YouTube has been the option of learning anatomy among students, suggesting its high prevalence in anatomy education (Joseph and Singh, 2019;
Mustafa et al., 2020). Nevertheless, video tutorials on cadaveric tools or models carried out by anatomy educators can supplement students with assured material accuracy (Barry et al., 2016).

Essential Anatomy, Anatomy, Learning, -3D Atlas, Teach Me Anatomy are alternative platforms (Khurana, 2020) available that allow learning to be scaffolded to promote visuospatial capability. Visual approaches from these channels have been reported to be useful in facilitating the retention and comprehension of the subject matter. In YouTube, dissection videos were the most widely viewed and have a positive attitude (Mustafa et al., 2020). The faculty has been recommended to develop a video on its own YouTube channels to support independent learning and integration in support of the current medical curriculum. However, there is a lack of quality educational YouTube videos and universities should encourage faculty to develop instructional videos that link to educational objectives as part of university knowledge transfer (Azer, 2012; Mustafa et al., 2020).

**Utilise Online Formative Assessment Principles**

*Online Formative Assessment*

The delivery of an online curriculum should favour a formative rather than a summative focus (Taha et al., 2020). Online training assessments (OFAs) have gained momentum in medical education, particularly as part of self-directed learning (SDL). The OFAs has many benefits for learners (Kavitha et al., 2018) and are also a method of self-assessment that provides input to both teachers and students (Rolfe and McPherson, 1995). Evidence reported on a web-based formative assessment to provide valuable learning experiences (Gikandi et al., 2011). Taha has recommended online assessment tools such as Socrative, Kahoot, Quizlet Live and Nearpod. However, studies have shown that student success is the same for conventional and online learning (Inuwa et al., 2011).

Several online teaching methods have been suggested, such as anatomical flashcards and digitalised spot-like tests with specific instructions on the updated examination format (Franchi, 2020b; Franchi, 2020a). Advancement in e-assessment, online synchronous or asynchronous assessment is evident when learning management systems (LMS) have a randomisation question/answer, digital drop boxes, and other tools built in to prevent dishonesty during the assessment (Evans et al., 2020). Google Drive, Microsoft Teams, WhatsApp, and Social Networks have also been proposed for students to work online (Reyna, 2020).

Likewise, anatomical online spotter review has gained more popularity over the conventional paper-based summative evaluation method (Inuwa et al., 2011). Inuwa commented that preferences were due to better quality specimens, simpler time management, and reduced anxiety. In addition, traditional spotter examinations have been reported to assess the lower order of Bloom's taxonomy (Choudhury et al., 2016). However, students have acquired anatomical knowledge confidently with the online anatomy assessment (Morris and Chirculescu, 2007) consisting of 20 sets of 5-part extended match or true-false problems, based on an analogy with immediate feedback to achieve a higher level of Bloom's taxonomy.

*Online Formative Feedback*

Authentic feedback is highly beneficial for online learning and promotes student learning. Education feedback is crucial (Bala et al., 2020), particularly as technology has taken over teaching and learning. Feedback should be given systematically by focusing on the feedback received (David CM Taylor and Hamdy, 2013). Strategies such as feedback via in-text activities, formative tutor-marked assignments, virtual tutorials, virtual groups, online support and discussion forums, and assessment (Taylor et al., 2020) are ways to be considered. Maintaining student interest and enthusiasm is one of the most critical issues of online teaching and learning. Timely feedback offers an excellent antidote in addressing such problems, as it assists students to self-assess and promote motivation stressed Taylor.
On this note, audio feedback has been suggested as an effective means of online feedback, as it retains the memory of the content (Orlando, 2016). Orlando stressed several benefits of voice feedback such as better understanding of nuance, taking less time with more feedback delivered compared to text, a sense of instructor caring, motivated and less isolated, holistic issues addressed, and more constructive. However, the large file size has been highlighted as an issue to manage via LMS but manageable via Cloud-based audio. In addition to this, screencast feedback has been reported to have higher acceptability that allows feedback in the form of moving images of the marker and the surroundings with audio (Mahoney et al., 2019).

Gaining Continuous Improvement by Evaluation

It has been reported that planned online learning practices are meaningfully different from those courses offered online as emergency remote teaching (Hodges et al., 2020). Hodges pointed towards valuable evaluation for emergency remote education during an infectious outbreak to focus on student learning outcome achievements, achieving the intended knowledge, skill and or attitudes, attitudinal outcomes, issues of motivation, and engagement. Entirely, online teaching and learning environment is a new experience for medical students. Thus, continuous evaluation for improvement is critical to ensure quality and successful online learning experience.

Students’ feedback on online teaching should be acquired following each session while more frequently by daily thoughts to help understand the issues faced by the student to make improvements. Online questionnaires to faculty seeking frequency of planned session, amount of resources allocated for each session, method of e-learning, feedback on students’ interaction with a proposal for enhancement has been proposed (Taha et al., 2020). The author stressed the significance of the information gained from the evaluation to enhance future practice. A qualitative study has also been recommended for students and staff experiences on completely online teaching and learning (Reyna, 2020).

Gaining Student Well-being through Mentoring Programme

Online Support and Mentoring Programme

It is essential to provide psychological assistance to medical students during the outbreak of communicable diseases. Learning in total isolation during this pandemic time can be very stressful, and thoughtful planning and development of courses potentially could ease students’ level of stress (Taha et al., 2020). Personal support for technology is crucial, and this can best be achieved by one to one meetings online or social networking meetings, such as WhatsApp (Taylor et al., 2020). Academic support for self-regulation strategies is essential to ensure online learning can be sustainable (Reyna, 2020). The author recommends several online tools to help students develop self-regulation, such as YouTube videos, evidence-based forums, and journal articles. Thus, a well-designed online course can support students’ academic and psychological well-being during difficult times.

Being mindful of delivering online materials and tasks for the day with timely feedback is crucial. Another important thing to consider is a consistent timetable with guidance and guidelines for the materials produced. Most importantly, the mentoring session made available during the current COVID-19 period creates a supportive environment for the students. In summary, the above consideration forms a guided step by step approach called 'Debug' to assist educators in designing online education, as shown below. Most notably, the mentoring session made available during the current cycle of COVID-19 provides a welcoming atmosphere for students. In summary, the above considerations form a step-by-step approach called 'Debug' to assist educators in the design of online education.
The five steps in 'Debug' guideline consists of the following fundamental principles to direct anatomists in creating high-quality online anatomy learning.

D- Design Learning – as an overarching concept

E- Educational Principles of CLT-bLM Model

B- Blended Online Teaching by asynchronous learning and

U- Utilise Assessment for Learning & Formative Feedback Principles

G- Gaining Continuous Improvement & Student Well-being by Mentoring Programme

Case Study

This paper is intended to share NUMed experience of designing learning for online anatomy education during the COVID-19 pandemic. The above guidance may assist anatomy educators in the design of learning by planning and implementing a design to create quality online learning for students. The Immediate Movement Control Order (MCO) halted all live lectures, and the only immediate response was to upload the PowerPoint slides to the NUMed LMS, the Medical Learning Environment. Secondly, ReCaps of previous years were made accessible to students to study from home.

Continuation of this act may potentially be devastating for students' learning and eventually to their well-being. Internet links are not always favourable to all students, and this has created a major obstacle to successful online teaching. Live lectures have been scheduled, but various time zones of our international students' have disabled faculty to move forward with this strategy. Another challenge was that not all faculty members were able to utilise specific technologies; hence faculty development was necessary to facilitate active online teaching and learning.

Worked example of NUMed Online Anatomy Education guided by the 'Debug' guideline.

- Firstly, the learning outcomes for the subject on the lower extremities were written explicitly.
- A selection of online anatomy learning resources was mapped to named, MLE as the main platform for all uploading of anatomy, materials, and communication centre to ensure the learning outcome is achieved successfully.
- The synchronous online meetings via Zoom and Teams were planned and asynchronous discussions/collaborations running over a longer period was planned to improve student engagement.
- A set of YouTube videos was selected to engage students in the topic and enhance retention.
- Clear expectations of the students with explicit indications of how the alternative activity continues to meet the learning outcomes of the module and the programme were communicated.
- Online formative assessment and feedback were designed to ensure the gap in understanding the topic was addressed and was conducted in the group as well as individual feedback strategy.

E- Educational Principle by Cognitive Load Theory-based Lecture Model (CLT-bLM)

- Firstly, lectures were segmented into a manageable portion to manage students' cognitive load. Information
chunking has been carried out according to the principles of segmentation to improve preservation. Sequencing the content of worked cases, tasks and input promotes cognitive capacity.

- The learning outcomes for the subject on the lower extremities were integrated into the presentation slides of the video lecture.
- The outline of the lecture was concisely written in simple words, keeping the points manageable.
- Slide training was aimed at cognitive engagement and the emphasis of the learners’ attention on content and reduced extraneous load was managed as below:
  - Plain background slides
  - Use of heading and subheading in a single slide.
  - Use of visual cues and signals: E.g., Arrows, and animation for attention focus.
  - Size and style of font: minimum quantity 24
  - Using text bolding, italicising and underlining.
  - Choosing a suitable colour scheme for readability
  - It is synchronised to all supplements.
  - Avoiding extraneous phrases, photos and animation that do not add to the content.
  - Managing diagrams-sized correctly, coloured and transparent, minimally marked. The complete anatomy App facilitated the preparation of the lecture slides for the lower extremities.
  - The app also offers a recording feature that allows recorded discussion of how to manipulate the dissected structures of the lower extremities.
  - Videos with voice recording over specific topics with screen slides for each topic developed. Screen slides are different from video slides, because screen slides allow students to control the image on the screen by rotating, zooming in and adding or removing layer structures.
  - After completion of individual video slides and screen slides, the slides are organized in PowerPoints.

b-Blending Synchronous Online Learning via Zoom

- The Zoom app was chosen by the anatomical team due to its simple connectivity, with accessible video and chat apps.
- The custom registration URL allows attendees to participate in the Webinar via Zoom.
- Zoom enabled recording; therefore, all webinar sessions were recorded for students to access later.
- The Clinical Reasoning Seminar was also conducted through the Zoom Webinar for a small group of (18-20) students.
- The first slide consists of a video of the femur, zooming around the femur. The video mimics PCap so that students can listen to the voice while the femur is projected.
- Discussion focused on the identification of the parts of the femur. The slide screen capture of the femur
model, with a fracture, enables comparison with an x-ray diagram.

- Students can rotate, zoom in-out, the femur model, and add some muscles, blood vessels, etc. A brief discussion and instruction were provided for a better understanding of the slide.

- The video recorded discussion on the parts and structure of the foot and leg, followed by a simulation of the pain of a patient with a fracture of the tibia.

- The model resembles the internal fracturing of the tibia and fibula bones, as students move the 3D model. For a better understanding, a concise description with an additional x-ray given.

- The following slide describes some slides with clinical correlations of the knee, ankle, and foot.

- The associated muscles, blood vessels, and nerve supply were further discussed.

- Usage of physically integrated format, by preparing related text information next to the diagram and preventing text and pictures on different slides with the verbal explanation provided.

- Creating interactive videos to engage the students and actively integrate them with the content presented in the video, encouraging learning attention and concentration.

**Interactive Activities**

- The active learning was facilitated with online spotters' test with immediate answers developed to promote engagement and motivation.

- Multiple choice questions (MCQs) and quizzes with immediate feedback on performance, with scores, were also presented on the screen.

- In order to optimise learning, interactive video with clips of simulated tibia-fibula fracture, where students were asked to identify the specific part of the bones, vessels and nerves involved could be affected in the fractured area.

- Answers to the questions were provided throughout the video.

**Delivering Phase**

- Partial instructor-led and partially student-led courses were planned with formal, compulsory meetings via zooming.

- The lecturer explained the purpose and encouraged a focus on learning outcomes and lecture outline.

- Prior knowledge, pacing and keeping instructions straightforward.

- A 5-10-minute discussion of the pre-lecture materials with an intra-lecture activity to promote active learning.

- The intra lecture activity consists of a series of rapid-fire questions to enhance understanding of the knowledge learned (ideally one intra-lecture event per lecture).

- Attention-enhancing techniques were introduced by pausing and asking, avoiding extraneous information, including visual cues to optimise the visual working memory.
**Analogies are learning through imagination by presenting real-life examples, and this mentally activates the pre-stored schema of the learners and applies to the present context.**

**The lecture integrates the content with previously learned information and correlate the data with real-life examples through the application of analogy via the complete anatomy App.**

**Facilitates learning by finishing the lecture with a verbal description and uploading a concept map summarizing the learned subject.**

**Disclosed goals by illustrating the learning result, by including references, by asking questions to trigger self-explanation, and by offering online consultation after the online session.**

**All lectures were recorded and uploaded into the MLE for students to access later.**

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**b-Blending Virtual Lectures by Flipping the Class**

- Pre-lecture materials were uploaded to the MLE 3 days before the lecture. Pre-lecture materials for students to watch before the lecture session was Powerpoint slides as well as YouTube videos linked to lumbosacral plexus and venous drainage of the lower limbs.

- The list of learning materials for case 24 was uploaded in the MLE with YouTube video links of lumbosacral plexus and venous drainage of the lower limbs.

- Short videos have also been attached to the MLE case 24 materials, where students can view and have some understanding of the situation related subject.

- All pre-lecture materials were sent to the students three (3) days prior to the lecture to provide sufficient time to read and prepare before the lecture session.

- The PowerPoints have video links to enable students viewing.

- Questions were provided for students to attempt after the series of short lectures with answers uploaded a week after the lecture session.

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**b- Blending laboratory practical with Asynchronous Online learning**

Anatomy laboratory practical session for the lower extremities under case 24 was conducted asynchronously. Learning materials and guides for students to access and use, such as online laboratory tutorials and laboratory handout guides, were uploaded to MLE 3-5 days prior to the session. The Complete Anatomy App was used to facilitate the tutorial session, which all students can access. The online laboratory tutorial includes short but comprehensive discussions on the topics that students should cover in their studies; it includes practical tests with answers that are immediately available upon submission.

Students were instructed to go through the online tutorial, after which they were advised to save the certificate of completion of the tutorial. The laboratory guide booklet contains the learning outcomes for the session and instructions for the study of the lower extremities. This guide also includes learning activity with anatomical figures for students to label. The Comprehensive Anatomy App acted as online laboratory session as students could virtually manipulate and dissect the structures of the lower extremities to facilitate visuospatial capability. Students can also use the App to access descriptions and labels for each structure of the lower extremities. The immediate answers
provided upon submission of the answers in the tutorial session.

Anatomy lectures were mainly conducted via Personal Capture (PCap) with ReCaps lectures from previous years. The software lets lecturers make, upload, and edit recordings. ReCap is an interactive lecture capture resource that captures audio and visual material and makes it available online.

**b-Blending with YouTube Videos**

Several YouTube videos were uploaded to MLE to align with learning outcomes. The first YouTube video selection describes the origin of the lumbosacral plexus, and the formation of its major branches within the posterior abdominal wall was evaluated for its quality and confirmed by the team to be used as part of blending the topic. While the second YouTube video describes the superficial and deep venous system of the leg. Both were assessed for their quality and suitability to flip the lecture session. Links were uploaded to the MLE for students to view, and clear instructions were provided for YouTube viewing and preparation for discussion prior to the scheduled live lecture session.

**u-Utilise Online Formative Assessment and Feedback Principles**

The Complete Anatomy App has been instrumental as an immediate remedy upon the lockdown order. Online quizzes and tutorials were planned for own pace and convenience via the App. Online spotters test for the lower extremities was developed with the App. OMBEA and Socrative were scheduled for subsequent anatomical sessions. Questions were developed after delivery of live online lectures and uploaded to the MLE for students to reply within a specified time frame.

Zoom combined with Microsoft Teams were used to conduct the session online. Two educators facilitated the zoom to conduct the session during which one of the educators used the PowerPoint slides to explain some of the concepts, and at the same time, students asked questions using the live chat or typed the questions in the chatbox.

The educators would then gauge the students' understanding of the topic and difficult concepts. The entire session was recorded for students to download and listen to the discussion as part of the revision. Microsoft Teams have been mainly used for online chat sessions to answer questions from the students. Year one and two groups were generated with the facilitation of the network by educators. As part of the round-up of case 12, a live question and answer chat (Q&A) session was held. When this was timetabled, we had a session attendance of a hundred per cent.

Students may access the chat at the end of the live session and use the conversation for purposes of revision. The response of the students was good with most students engaging at their own pace to clarify post-reading session doubts, pre-lecture materials, or post-tutorial. This promoted a humanistic, student-friendly environment and students were able to access the chat room at their convenience.

*Online spotters' feedback:*

To access the Complete Anatomy App, students were provided with the link: the online spotters, diagrams with questions given to students to attempt. Once the assignment is complete, a window will pop up for students to show the feedback. It encourages student's motivation and increases participation in future spotters' test.

To access the Complete Anatomy App, students were provided with the link: the online spotters, diagrams with questions given to students to try. Once the assignment is complete, a window will pop up for students to show the
feedback. It encourages student's motivation and increases participation in future spotters’ test. Students were given three consecutive days to do the online spotters following the case 24 round-up. This is then removed, and all students were sent email print screens of each correct answer to serve as formative feedback. Students have been encouraged to email the lecturers for more clarification if it is required.

g- Gain Continuous Improvement by Evaluation

The university performs end of case review for all the subjects as part of a continuous improvement strategy. The students were therefore required to complete the case evaluation via the MLE portal. Following are the sample results from last year's case 24 evaluation.

1. What aspect of the case material on the MLE was beneficial helpful or could be enhanced?

'The online study helped me provide an idea of all that would be included in the case and how important it would be in that situation.' - Student A.

'The MLE case was easy to follow and followed the course of lectures' - Student B.

'We have good cases and seminars and TBLs where we learn the most. It doesn’t matter with the virus now so add more seminars and TBLs’ - Student C.

2. What are the best traits of the case?

'All of the lecturers involved in this case have been excellent at delivering teaching materials. It is obvious that they are expert in the field that they teach in and the information they provide is easy to understand and intellectually stimulating' - Student A.

'The anatomy session was well planned and inspired by the spotter test’ - Student C.

3. How could the case be improved?

'Should spread the case over a longer span' - Student D.

'Organize more anatomical quiz to help memorize’ - Student E.

'More questions on SDL SBA / SAP for better understanding’ - Student C.

During the MCO, evaluations were made verbally via Zoom during the mentor-mentee meetings. Students were dissatisfied with the audio quality of the ReCaps uploaded and therefore struggled to understand the content. Several students chose to treat the anatomy models directly, rather than online 3D models. The students often tended to study in groups rather than alone, while a few favoured teachings in the classroom for greater focus and active involvement. Internet access has been a challenge in some regions and so countries have struggled to download online documents. The end-of-case feedback was obtained from the students using the online form.

Team meeting was held to discuss and plan to respond to the informed feedback for further improvements on subsequent case launch. Strategies for improvement were identified, and an action plan was drawn up explicitly for each established need. Requirements for prioritized online development were established, such as low voice recording and difficulty in understanding uploaded lectures. Some of the issues highlighted were the downloading of ReCap lectures from previous years as immediate help during MCO leaving little time for the lecturers to do the new lecture.

The Action Plan was developed to create a new lecture session to be uploaded to the MLE. Asynchronous learning mode was designed for immediate clarifications after the lecture feedback, through Zoom / Microsoft Teams.
Anatomy lectures and practical laboratory materials were scheduled for revision in order to address some of the immediate feedback highlighted. The team will implement the planned strategy for the coming semester. The progress of Case 24 will continue to be assessed for improvement.

**Gaining Students Well-being**

The academic mentors assigned to the respective mentees would follow up on the well-being and academic progress of the MCO via e-mail and Zoom. Academic mentors and mentors have been in constant communication about the student's whereabouts and have dealt with the student's issues, referring to learning skills that support academic difficulties and university Pastoral Support for personal issues. Academic mentors and mentors have been in constant communication about the student's whereabouts and have dealt with the student's issues, referring to learning skills that support academic difficulties and university pastoral support for personal issues. It was made possible by university MLE and responsible contact person emails that were open to all students.

**Issues handled by the University during the disruption:**

Some students were confined to the University Hostel during the MCO and were unable to return home. NUMed supported students with basic needs, such as providing food twice a day and etc. Academic mentors have been in constant communication with students, which has given students a sense of security during a stressful period. Secondly, internet access in the hostels was assured to function at the pace needed for the University to operate smoothly at its full ability to safeguard online teaching. Pastoral Support counselling was extended to all students experiencing emotional issues. Students who were worried about the forthcoming final exams were referred to the Student Support Group for advice on getting improved study skills.

**Conclusion**

Learning design is becoming a popular term now that everyone has been wedged at home for months. The industry, professors and students have seen e-learning in a new light. And in the limelight, with all the benefits, online anatomy education should be designed and introduced as part of the Recovery Movement Control order (RMCO) to ensure the full online subject is delivered to support students’ learning. The 'Debug; guideline can be potentially a guiding companion to anatomy educators to plan anatomy education online, taking into account the critical elements that should be integrated during the disruption time into entirely online teaching and learning.

**Take Home Messages**

Improvements in technology have made online a more accessible option for traditional colleges and universities. This guideline, when planned and developed systematically, could enhance the anatomy learning environment.

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Appendices

None.
Declarations

The author has declared that there are no conflicts of interest.

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Ethics Statement

The evaluation information is part of an evaluation exercise of our educational continuous quality improvement activity. This is a routinely collected data following completion of teaching activity. Verbal informed consent was obtained from all subjects before the study. All anonymity has been preserved to minimise the harm of ethics. Ethical approval was not required for this because it is not reporting research findings.

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