EDUCATIONAL RESOURCE

e-Anatomy Kit: An Innovative and Hybrid Tool for Gross Anatomy of Respiratory System Digital Practical

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ABSTRACT

The COVID-19 pandemic significantly affects medical education in anatomy. The new learning environment has lost face-to-face contact, cadaveric dissection, and access to anatomy museum which are perceived as the signature methods in anatomy education. e-Anatomy Kit is a non-conventional teaching modality innovated as an alternative to the gross practical session. The e-Anatomy Kit was designed to improve the virtual practical experience for first year medical students of the Faculty of Medicine, Universiti Teknologi MARA, Malaysia. e-Anatomy Kit consists of: (a) pre-recorded cadaveric demonstration, (b) 3D4Medical Complete Anatomy app, (c) interactive diagram labelling, (d) schematic diagram, and (e) mnemonic. From educational perspective, the e-Anatomy Kit is in line with the active learning approach and collaborative learning; its instructional design follows the principles of the Cognitive Load Theory. This article describes the components and systematic approach of e-Anatomy Kit as a new method for teaching gross anatomy of respiratory system during virtual practical, which is useful for anatomy educators.

Keywords: *Anatomy, e-Anatomy Kit, teaching and learning, online and hybrid platform*

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INTRODUCTION

The impact of Coronavirus Disease 2019 (COVID-19) and disruption on medical education has been unprecedented with educational institutions being placed on lockdown (1, 2). This event resulted in the disruption of in-person teaching format of anatomy as one of the basic subjects in medical schools. Hence, the conventional anatomy teaching and learning (T&L) involving resources such as cadavers, bone banks, prosected specimens, models, and microscopic slides via the face-to-face teaching were compromised (1).

The medical schools need to quickly adapt and adjust their T&L during COVID-19 pandemic by shifting to online distance learning (ODL). Practical session was transformed into electronic-based T&L with various blended materials of interactive online learning. Usage of virtual dissection media, interactive software, and open-access content were increased in most of the medical schools (3).The demonstration was conducted through pre-recorded videos, live streams from the dissection hall, or website using Acland's Anatomy (4). The other alternative is three-dimensional human body apps such as 3D4Medical Complete Anatomy and Visible Body etc. (5).

To date, there is limited established pedagogy and assessment strategies for online learning, which are necessary for implementation of effective online learning (6, 7). The COVID-19 pandemic has sparked innovative ways to give students the optimum learning experience, complemented with evolving high-tech innovations to students together with other innovations (6).

Therefore, e-Anatomy Kit was invented as a non-conventional hybrid tool for virtual practical of gross anatomy of respiratory system during the COVID-19 pandemic. The kit consists of: (a) pre-recorded cadaveric demonstration, (b) 3D4Medical Complete Anatomy app, (c) interactive diagram labelling, (d) schematic diagram, and (e) mnemonic. The e-Anatomy Kit served as a remote anatomy

learning which could be an alternative to cadaveric practical or other learning materials that are usually used during face-to-face teaching (6).

BENEFITS OF E-ANATOMY KIT FROM MEDICAL EDUCATION PERSPECTIVE

3D4 Medical Complete Anatomy app is a software application which portrays the three-dimensional (3-D) structure of the human anatomy. The use of 3-D technology in the study of human anatomy improved the ability of medical students to visualize structures in 3-D (8) and enhanced students' performance in examination (9). Cadaveric demonstration and schematic diagram are visual representation that facilitate visual model-based reasoning (10). A study by Chung et al. revealed that schematic diagram helps the students to memorize the facts they learned in anatomy and improved their anatomy assessment results (11).

Mnemonic helps the students to memorize facts for a long time. This powerful way to learn huge amounts of information consists of word associations, visual images, and stories (12, 13). Mnemonic requires incorporation of imagination, visualization, and creativity, resulting in an enjoyable learning process (11). Mnemonic enhances understanding and memory retention, and improves the students' performances (14).

Interactive diagram labelling is a form of game-based approach that has received an increasing attention in medical education and is being used as a teaching tool (15). Rondon et al. demonstrated that students who were taught using game-based method performed better in post-test assessment and it has been said to be comparable with traditional learning method in general (15, 16). These activities were proven to be enjoyable and effective, low cost, and promote engagement (15, 17).

In educational perspective, the new combination of various methods used in e-Anatomy Kit is in line with the active learning approach and collaborative learning principle (18) and the kit's instructional design follows the principles of the Cognitive Load Theory (CLT), which reduce their cognitive burden via stimulation of cognitive engagement and motivation (19). CLT is an instructional design theories that asserts optimum learning when instructional materials are structured and operate in accordance with the architecture and function of human cognition (20). Working memory, the core of CLT principles, converts raw sensory memory data into meaningful schema, which is then transferred to long-term memory for working memory system (21).

Collectively, the central tenet of learning anatomy is to understand the anatomical structures, which can be achieved only when the learners are able to mentally visualize images of the anatomical structures and designed diagrams that can facilitate visuospatial learning and enhance cognitive learning techniques (22). Thus, integration of various tools in e-Anatomy Kit was done for the first time using virtual practical approach in this remote online learning following COVID-19 pandemic.

E-ANATOMY KIT APPROACHES FOR GROSS ANATOMY OF RESPIRATORY SYSTEM DIGITAL PRACTICAL

This section describes a systematic approach on using e-Anatomy Kit as a teaching and learning tool for virtual practical session of gross anatomy of respiratory system.

Pre-practical Activity

Prior to the virtual practical session, the students were given a general briefing about e-Anatomy Kit. The learning outcomes of the virtual practical session for respiratory system was provided. At the end of the session, students are expected to be able to:

a. identify the gross anatomy of thoracic cage, intercostal space, intercostal muscle, and diaphragm,

b. identify the gross anatomical features of the medial and lateral walls of nasal cavity,

c. identify the gross anatomy of trachea, lung, and pleura, and

d. identify the gross anatomy of larynx and pharynx.

Students were encouraged to switch on their webcam to enhance interaction with lecturer. During the practical session, the flow of the usage of e-Anatomy Kit was briefed, which consists of recorded cadaveric demonstration (20 minutes), followed by 3D4 Medical Complete Anatomy app (15 minutes), schematic diagram (30 minutes), mnemonic (10 minutes) and lastly interactive picture labelling activity (15 minutes) (Figure 1). The virtual practical session took about 1.5 hours.
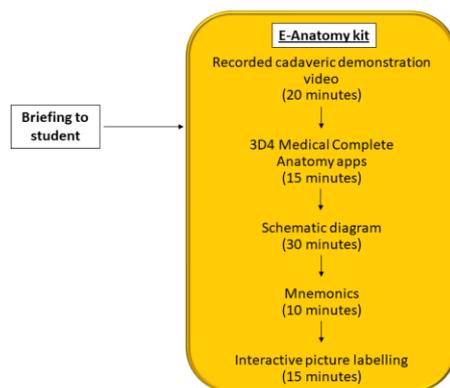

Figure 1: Flowchart for gross anatomy virtual practical of respiratory system using e-Anatomy Kit via online platform

Recorded Video Demonstration of Cadaver

The main objective of the recorded video demonstration was to demonstrate the respiratory organs and their salient features in cadaver. The video demonstration highlight was divided into three parts that highlight different parts of the respiratory system.

In part 1, thoracic cage, intercostal muscles, and diaphragm were highlighted. The skeleton of the thoracic cage was first shown, with salient features for each type of the ribs were highlighted. The ribs, intercostal space, and muscles were identified. The differences of each muscle were discerned. Lastly, the diaphragm and its features were shown.

In part 2, the sagittal section of the head and neck wet specimen was highlighted, showing the nose, nasopharynx, larynx, and laryngopharynx. The external nose and structures in the nasal cavity including the floor, roof, medial and lateral wall were identified. The pharynx and its subdivision (nasopharynx, oropharynx, and laryngopharynx) were identified. Then, the larynx, its related cartilages, and membranes were introduced.

In part 3, the trachea, lungs, and pleura were demonstrated. The trachea and its division as well as tracheal ring were shown. The borders, surfaces, lobes, and fissures of both lungs were identified and explained.

Demonstration Using 3D4Medical Complete Anatomy App

3D4Medical Complete Anatomy app is a licenced application purchased by the university from Elsevier. The main objective of this session is to familiarise the students with the anatomical

orientation of the respiratory organs, as well as performing virtual dissection to expose structures in the respiratory system.

Firstly, the respiratory organs and their anatomical positions were shown, followed by identification of the external nose and nasal cavity. The medial wall and lateral wall of the nasal cavity were virtually dissected and identified. Then, the position of the pharynx and its division, the larynx, and the trachea were shown. After that, the technique on how to identify the anterior and posterior borders of the lungs and parietal pleura were demonstrated (Figure 2).

Schematic Diagram

The students were guided on how to draw the schematic diagram of the lateral wall of the nasal cavity and its opening. The diagram was drawn in Microsoft PowerPoint with white background and explanation were done simultaneously. Step-by-step schematic diagram was shown of lateral wall of the nose and the structures which open into it.

The schematic outline of medial view of the lateral wall of the nasal cavity was drawn, including frontal sinus and sphenoid sinus, followed by conchae, meatuses, and sinuses which open into the lateral wall of nasal cavity. The sinuses which open into the lateral wall of the nasal cavity were symbolized in coloured circular shapes (Figure 2).
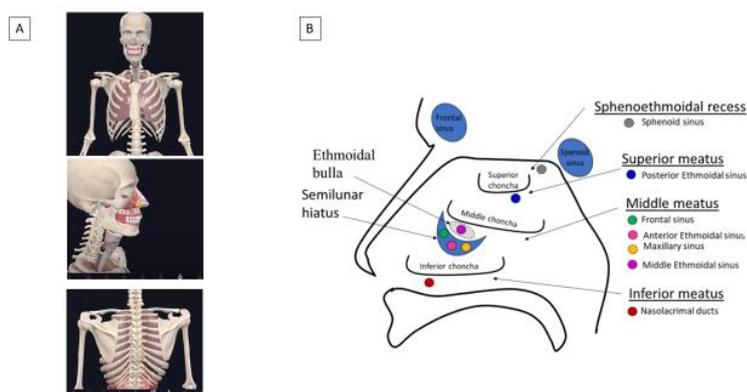
Figure 2: e-Anatomy Kit consisting of A) 3D4Medical Complete Anatomy app, B) Schematic diagram showing lateral wall of the nose and the structures which open into it

Mnemonic

The usage of key words, rhyming words, or acronyms are the basics of mnemonic method. Mnemonic related to respiratory system was introduced and explained in the e-Anatomy Kit using Microsoft PowerPoint (Figure 3).

Mnemonic covered the topic on the vertebral level of the opening in the diaphragm and its major content, which utilized the keyword technique. The mnemonic is, "I Ate 10 Eggs At 12pm" which from the way the words are pronounced, represent the following anatomical structures:

I	=	inferior vena cava
Ate	=	T8 vertebral level
10	=	T10 vertebral level
Eggs	=	oesophagus
At	=	aorta
12pm	=	T12 vertebral level

The mnemonic is interpreted as, "there are three openings at the diaphragm: at vertebral level of T8 which is traversed by inferior vena cava, at vertebral level of T10 which is traversed by oesophagus, and at vertebral level of T12 which is traversed by aorta".

Interactive Picture Labelling

Interactive picture labelling is an interactive online learning quiz. The objectives for this quiz are for the students to be able to identify the components of the thoracic cage, lungs including their fissures, borders, and root, and diaphragm including its openings and parts. This quiz is developed to mimic the face-to-face practical session in which students were provided with pictures of the cadaveric specimens with the key points of the learning outcomes.

Before starting the quiz, students were invited to join the Inknoe ClassPoint app using the class code and the website link provided in the chat box. Each group was allocated to label one exhibit from the quiz. Discussion was then conducted on the labelled exhibit with all the students. The labelling and discussion of the exhibits were done for all the exhibits provided in the quiz (Figure 3).
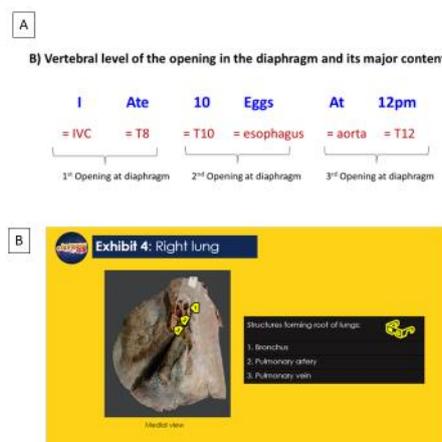

Figure 3: e-Anatomy Kit consisting of A) Mnemonic showing opening and contents in diaphragm, B) Interactive picture labelling quiz of the lung

Considerations when Using e-Anatomy Kit

As e-Anatomy Kit is conducted using online platform, both the students and lecturers need to have good internet connection to ensure the program is running well. As some students may face intermittent loss of internet connection, a recorded session was provided to the students at the end of the session for student to revise.

The diversity of T&L mode provided by e- Anatomy Kit is also applicable to be used as one of the learning materials that can supplement the face-to-face practical session once it is made available in the future. The 3D4 Medical Complete Anatomy app usage is limited to the institution that subscribe to it. However, the recorded version of e-Anatomy Kit can also be used as a reference by learners without 3D4 Medical Complete Anatomy subscription.

e-Anatomy Kit materials were also designed as a self-learning material that can be repeatedly used by the students as revision after the live session. It can also be used as complementary learning even when face-to-face practical session is resumed. Hence, the kit encourages andragogy concept of learning which is important in developing mature learners. However, the kit's usage is dependent on students' motivation to learn, their learning capacity, and preference of the different materials provided.

CONCLUSION

The new combination of various methods used in e-Anatomy Kit is in line with the active learning approach and follows the principles of the Cognitive Load Theory (CLT) by reducing cognitive load for maximal learning capacity. e-Anatomy Kit is ostensibly useful for the anatomy educators for prospective advancement in anatomical education.

CONFLICT OF INTEREST

The authors declare no conflict of interest. Formal permission was obtained from Elsevier which owned 3D4 Medical Complete Anatomy app for this article.

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