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Approaches for online teaching of practical veterinary anatomy and biochemistry during the COVID-19 pandemic at the University of Zambia: an online search of complementary cyber pedagogy techniques

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Abstract

The COVID-19 pandemic has brought some challenges in the delivery of practical-based curricula such as veterinary anatomy and biochemistry. When compared to the face-to-face mode of delivery, online delivery of comparative veterinary anatomy and biochemistry lacks the hands-on training obtained during the face-to-face mode of delivery. Of particular concern is the lack of real hands-on experience such as cadaveric dissections, experimentations in biochemistry and the lack of objective assessment of students. Challenges associated with online teaching of practical-based courses may result in compromised quality of graduate veterinarians. It is therefore important for educators in practical comparative veterinary anatomy and biochemistry to be fully aware of the availability of various online methods including their advantages and disadvantages when compared to the face-to-face mode of delivery. In this review article, we have provided some insights into some selected methods and software that are available online that can be used in the delivery of online practical comparative veterinary anatomy and biochemistry. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) was used to search the literature for information on online teaching of practical comparative veterinary anatomy and biochemistry. The literature search retrieved a number of articles on online delivery of practical veterinary anatomy including or IVALA, 3D Canine Anatomy and IMAIOS Vet-Anatomy. For Biochemistry several online based or virtual demonstration laboratories exist as well as open-source software for molecular visualization. The advantages and disadvantages of some selected cyber pedagogy technics are discussed.

Keywords: Pandemic, COVID-19, Veterinary Anatomy, Biochemistry, Online Teaching, Zambia

1. Introduction

The Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2 or Covid-19 pandemic) which started in Wuhan, China in December 2019 has since spread throughout the world and has continued to wreak havoc in many countries (Simukoko and Mujuni, 2020-inpress). Due to the global spread of the SARS-CoV-2, several countries have gone into complete or partial lock-down in order to curtail the spread of the pandemic. The lock-down measures taken to deal with the spread of the pandemic have negatively affected the education system at all levels including higher education. Most countries in the world including Zambia shut down universities in order to curb the spread of the pandemic. In Zambia, veterinary education at both postgraduate and undergraduate levels has been negatively affected. Two main reasons for shutting down the universities have been advanced: (i) for the safety of students and lecturers and (ii) to prevent students from becoming the portal of spread of the disease (Sahi et al., 2020; Rose, 2020).

The social distancing measures during the covid-19 pandemic have precluded the conduct of classroom-based teaching (Sahi et al, 2020). The lack of classroom-based teaching has negatively impacted gross anatomy courses and cadaveric dissection laboratories (Fleagle et al., 2018). At the University of Zambia, School of Veterinary Medicine, only final year students were permitted to return on campus under strict social distancing rules. Students in the other years were not allowed on campus and lectures for these students were strictly conducted online using various forms of cyber pedagogy. The sudden shift in the pedagogical methodology from face-to-face to cyber pedagogy has undoubtedly created some adaptation shocks. Of particular concern has been the total disengagement from hands-on practical sessions in veterinary anatomy and biochemistry which may impact

negatively on the quality of future veterinary graduates. The current students of veterinary anatomy and biochemistry who have been affected by the lock-down will be comparatively deficient in the practical aspects of the two courses. In order to mitigate the deficiency, there is need for educators in veterinary anatomy and biochemistry to be able to effectively utilize various methods of online delivery of veterinary anatomy and biochemistry. In this article we have provided a synopsis of the curricula in veterinary anatomy and biochemistry as taught at the School of Veterinary Medicine, University of Zambia and have provided insights into how the various components of the curricula can be adopted for cyber pedagogy (online teaching). Various methods for teaching practical veterinary anatomy and Biochemistry were identified and assessed through an online literature search using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method. We believe that the available online methods for teaching practical aspects of veterinary anatomy and biochemistry can be useful in bridging the gap created by the sudden shift from hands-on face-to-face engagement to purely cyber pedagogical methods.

Face-to-face and online teaching at UNZA

Before consideration of the different cyber pedagogical techniques that can be used for teaching practical veterinary anatomy and biochemistry online, a synopsis of the current face-to-face veterinary curriculum is given. This has been done in order to identify the deficiencies that may occur when delivering the veterinary anatomy and biochemistry curriculum via online methods.

Current Veterinary Anatomy Curriculum at UNZA

The University of Zambia is a dual mode institution with distance learning mode and face-to-face mode of study running parallel to each other while utilizing the same resources (Simui et al.2018). Distance education has been in existence at the University of Zambia since 1966 (Simui et al. 2017; Simui et al. 2017).

The face-to-face veterinary anatomy curriculum at the School of Veterinary Medicine, University of Zambia is taught over a period of two years with each year consisting of two terms. The first part (second year of programme) of veterinary anatomy involves teaching gross anatomy, histology and embryology. The second part (third year of veterinary programme) of veterinary anatomy involves teaching of comparative and applied veterinary anatomy. The university of Zambia follows a two-term system with each term consisting of about 30 weeks.

Year 2 programme of Veterinary anatomy at UNZA

At the School of Veterinary Medicine of the University of Zambia, the first year veterinary students (who are in the second year of programme) start by first learning gross anatomy which involves mastering the nomenclature. directional terms used in veterinary anatomy. The veterinary anatomy nomenclature is taught based on the NominaAnatomicaVeterinaria (N.A.V), a compilation of terms which is published by the World Association of Veterinary Anatomists.

After the students have been taught the nomenclature and directional terms, they are then introduced to systemic anatomy which deals with the study of discrete anatomical body systems. Face-to-face lectures on the anatomy of all body systems ranging from the musculoskeletal to the integumentary system are considered in detail. After learning systemic anatomy, the students are taught topographic and regional anatomy. The lectures are mainly lecturer-controlled and information centred. The lecturer talks while the students are mainly passive listeners. Students may be allowed to ask questions during or after the lecture. The lecture serves four main purposes: (i) To explain concepts (ii) It is a time for clarifying concepts (iii) To review topics (iv) To motivate. The methods used for the teaching of veterinary anatomy involves dissections, interactive multimedia, procedural anatomy, surface and clinical anatomy, and imaging (Sugand et al., 2010; Hackman et al, 2020).

The lectures are given concurrently and in synchrony with practicals which involve mainly cadaveric dissections of canine (dog) cadavers. During the practicals, the instructor (who is a qualified veterinary anatomist) performs demonstrative dissections for the students. This is done by first giving a synopsis of the specific practical to be done and providing guidance on the procedures involved. Thereafter the students continue to perform the dissections on their own following the steps prescribed in the department laboratory manual under the guidance of the instructor.

The practical sessions run once every week for three hours during each term. The students work in groups of 4 and are encouraged to discuss the dissections and relate their findings to the theory lectures. Each student in every group has the opportunity to perform the dissections.

Continuous assessment tests are given in both the theory and practical components of veterinary anatomy. At least three theory tests and one practical test are given during each term. The practical tests involve the identification of anatomical structures which may be done in spot check fashion. In every practical test session, there are usually at least 15 stations containing specimens which the student must identify and/or write something about the functional anatomy of the indicated structures. A student must spend 1.5 minutes per station before moving to the next station. In addition to performing dissections on cadavers, students also handle both large and small live animals to appreciate the topographic anatomy on live animals. Final theory and practical examinations are also given at the end of the year.

Histology and Embryology

At UNZA School of veterinary medicine, histology is combined with embryology as one course. The students are first taught cytology and then general histology. Later The students are also taught histology and embryology.

The teaching of histology and embryology is also done concurrently and in synchrony with the practicals. The practicals in cytology and general histology involve mainly observation of tissue specimens under a light microscope. This is done under the supervision of a demonstrator/lecturer who is a qualified veterinarian. Demonstration microscopes are used to explain the various histological slides to the students. Later, the students examine the histological slides on their own with minimal supervision. In embryology, histological slides of embryonic tissue are studied. In addition, foetal specimens are obtained from local cattle and goat abattoirs for students' practicals. Theory and practical continuous assessment tests are given every term. At least three theory tests and one practical test are given.

Year 3 programme of Veterinary anatomy at UNZA

Comparative and Applied Veterinary Anatomy is conducted after the students have completed the systemic anatomy and regional anatomy which is done in year 2. Comparative and applied veterinary anatomy covers anatomical and physiological differences between selected animal species. The animal species covered include ruminants, equine, porcine, canine, avian and piscine species. Students gain knowledge on how to relate appropriate anatomical information to clinical situations in selected domestic animals, domestic fowl and bony fish. In this course, the lectures are given concurrently and in synchrony with practicals which involve cadaveric dissections of the small ruminants, the horse, dog, domestic fowl and fish. During the practical sessions, students actively participate in cadaveric dissections by using a prescribed laboratory manual under minimal supervision from a demonstrator or instructor who is a qualified veterinary anatomist.

Continuous assessment tests are given in both the theory and practical components of comparative and applied veterinary anatomy. At least three theory tests and one practical test are given during each term. The practical tests and examinations involve the identification of anatomical structures in a comparative manner.

Current Biochemistry Curriculum at UNZA

Biochemistry course consists of three teaching components (i) Theoretical component taught through three hour (split into two and one hour) lectures per week (ii) One hour tutorial per week and (II) three hour practical session per week. The practical component is meant to give an in-depth understanding of theoretical facts presented during lectures. Biochemical concepts are better understood with a good understanding of molecular structures. One way of appreciating the existence of such molecules is by way of using the practical sessions to explain the role or function of the learnt molecular structures as they occur in pathways. This is in line with the definition of biochemistry which is the study of life at molecular level. The presentation of the course material spans over thirty weeks split into fifteen weeks of learning per term. In the normal face to face learning, the course is assessed through two components.

(i) Continuous assessment which makes up 40% of the overall course assessment. The 40% continuous assessment is broken up into 30% written tests/assignments and 10% laboratory work presented as laboratory reports. (ii) The final written examination administered in three hours at the end of the academic year contributes the remaining 60% for overall assessment of the course.

Cyber pedagogy (online) methods used at UNZA

UNZA currently uses the Astria and MOODLE e-learning platforms. The use of the two E-learning platforms had been increasing steadily over the years but the outbreak of the COVID-19 pandemic caused an almost 100% utility of the two platforms.

Moodle (an acronym for: Modular Object-Oriented Dynamic Learning Environment) is an open-source Learning management system (Seluakumaran et al., 2011). The COVID-19 pandemic brought about a complete shift in the method of lecture delivery that saw the MOODLE platform being taken up as the major e-learning platform by all units at UNZA.

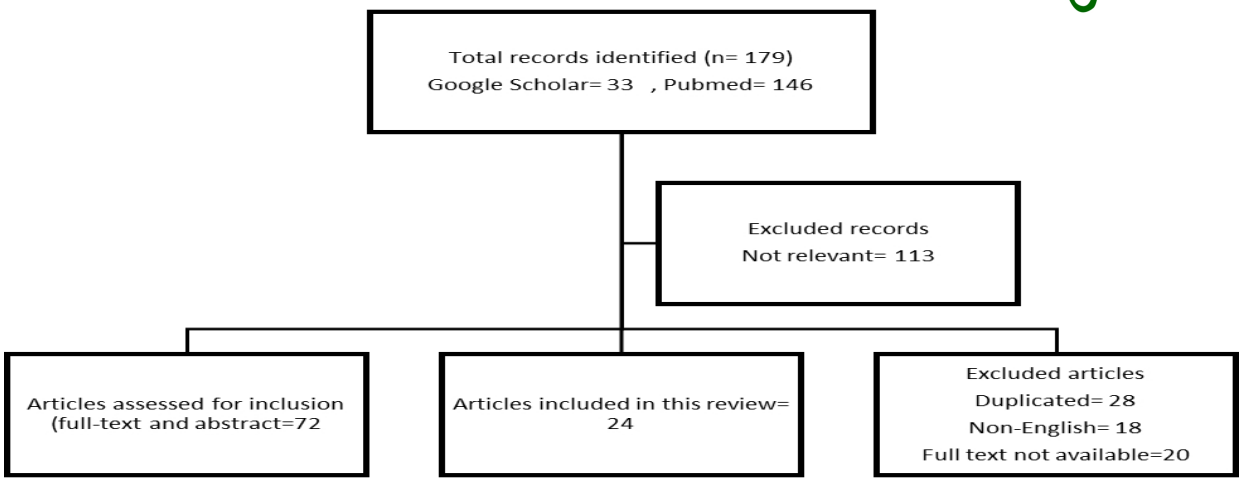
Astria E-learning is a commercial cloud-based learning management system that is designed to help students learn activities in a systematic manner. Astria platform was initially a platform reserved for distance students under the Institute of Distance Education, but the advent of the COVID-19 pandemic has seen an increase in its utility by other units of the University of Zambia. Undoubtedly, the MOODLE and Astria platforms have contributed immensely to ensuring relative smooth continuity in pedagogy after the outbreak of the COVID-19 pandemic.

The general disadvantages of teaching and learning online via Astria and MOODLE include social isolation and high potential for cheating. Teaching practical-based courses such as veterinary anatomy and biochemistry presents even more challenges in that the face-to-face hands-on practical cadaveric dissections and experimentation are almost completely obliterated from the pedagogy and yet the practical components form the core of these courses. In this regard, identification of software that may approximate to the hands-on face-to-face practicals is cardinal in bridging the gap in this deficiency. Thus, an online search was conducted to identify some selected software that could be used to complement the Astria and MOODLE learning platforms for practical-based courses such as Veterinary Anatomy and Biochemistry.

2. Cyber Ppdagogical methods for teaching veterinary anatomy and biochemistry

Search strategy

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines for systematic review was used to conduct a literature search by searching PubMed and Google Scholar databases to find relevant information related to online teaching of



Veterinary Anatomy and Biochemistry. The conceptual diagram of the literature search is shown in figure 1.

Figure 1. Conceptual framework of search strategy (Janssens et al., 2020)

Pubmed search

Pubmed searches article citations from over 5,000 biomedical journals. It is a free search engine accessing primarily the MEDLINE database of references and abstracts on life sciences and biomedical topics. The United States National Library of Medicine at the National Institute of Health maintains the database as part of the Entrez system of information retrieval (Lindberg DA (2000). Pubmed remains an optimal tool in biomedical research (Falagaset al, 2008)

In Pubmed there are two basic ways to search and retrieve publications using words or phrases in the text word search box of pubmed or using the Medical Subject Heading database called MeSH. In this study, both search techniques were used to retrieve publications about online teaching and learning in anatomy and biochemistry. Using the text word searching technique, the phrases "online teaching and learning in veterinary anatomy" and "online teaching and learning in biochemistry" were used to search for publications.

The text details box was checked to see how Pubmed had interpreted the search. In this case Pubmed had correctly mapped the search to the appropriate MeSH headings: ("online, teaching learning "[MeSH Terms] OR ("veterinary Anatomy"[All Fields] AND "Biochemistry"[All Fields]) OR "anatomy"[All Fields]

This mapping enhanced the search to ensure that articles on the topic were not missed. This meant that Pubmed also searched the text words in all fields of the citation i. e. the article title, abstract and journal source. The articles may or may not have been specifically about online teaching veterinary anatomy and biochemistry. The terms may have been used in the title or abstract or in some other context. The same search was done using the MeSH database. The MeSH search yields a more focused search since it uses terms used by indexers to describe what each article is about. When using the MeSH database each concept of the search phrase was keyed in separately.

After performing this search, 64 publications were retrieved for the search phrase "online teaching and learning in veterinary anatomy" while the search phrase "online teaching and learning in biochemistry" retrieved 82 publications. The publications were further filtered based on whether they were published in the last 10 years or whether the abstracts or full articles were available in English.

Google Scholar search

In Google Scholar, multiple searches were conducted by adjusting key words with each search. The search was filtered based on the period of interest (in this case over the last 10 years-2010 to 2020) and whether the abstract or full articles were available in English. In Google Scholar a total of 33 articles were retrieved.

After performing the Pubmed and Google Scholar searches, the articles were further assessed for inclusion or exclusion based on relevance to the review. A total of 24 articles were included for purposes of this review.

Eligibility and Inclusion criteria

The focus of the search was on articles that were related to information about online teaching of veterinary anatomy and biochemistry published between 2010 and 2020. The information of interest that was extracted from the retrieved articles included description of various methods and challenges associated with online teaching of veterinary anatomy and biochemistry. Also, some articles that described general methods of teaching online were included in the review.

Exclusion criteria

Articles that were excluded from this review were those containing abstracts without available full text and articles in other languages other than English as well as articles unrelated to the objective of the search.

3. Results

Of the abstracts identified from the search, 33 full-text papers met the inclusion criteria. Data extraction was completed on 24 papers of high methodological quality.

Analysis of search results

The various online teaching methods that were retrieved after the search are summarized in table1 and

each method was further described and assessed in terms of its advantages and disadvantages particularly in relation to their use in resource poor settings in the advent of the covid-19 pandemic.

Table 1. Online methods used for teaching veterinary anatomy

Method	URL	Cost
IVALA	https://www.ivalalearn.com/3d-content/	£60.00
3D Canine Anatomy	https://play.google.com/store/apps/details?id=com.biosphera.doganatomy&hl=en	Variable
IMAIOS Vet-Anatomy	https://www.imaios.com/en/vet-Anatomy	Variable

i. IVALA

Description: IVALA is an online 3D virtual veterinary anatomy software that provides the student and lecturer with various anatomy topics in an interactive fashion. The software has good graphics and allows the user to self-study various animal body systems including clinical applications. This software allows the student to pick apart bones, muscles, eyeballs, the heart and other organs. The software can allow first- and second year veterinary students learning veterinary anatomy for the first time to virtually dissect, explore and test themselves. In addition, clinical year students and experienced clinicians can review the anatomy relevant to surgical and medical procedures (Little et al., 2018). The software is available in English.

Cost of accessing: The annual subscription for this software is 60 British Pounds. With this subscription, the user has access to all 3D content, access to all flashcard content, access to all Multiple-Choice Questions (MCQ) content as well as access to all future updates.

PC specification requirements: Since the 3D images in this software are animated, the users' PCs must have the appropriate specifications. This means the PC should have the right processor (CPU), Graphics card (GPU) and Memory (RAM)

Recommendations: Despite the relatively high cost, this software would be useful for students in institutions based in low-income countries such as Zambia. There would be need, however, for the institutions to provide consistent annual subscriptions.

ii. 3D Canine Anatomy

Description: The Canine Anatomy 3D software, is a virtual dog (German Shepherd) that is designed especially for students, lecturers and veterinary clinicians. It allows viewing systems one by one, or in any combination, at different angles and degrees of approximation. It is a great start to study or teach veterinary anatomy. The software is available in English, Brazilian Portuguese, Spanish, French, German, Japanese and Latin. The anatomy of the major systems including the nervous system, digestive system, urinary system, lymphatic System, respiratory system, circulatory system, skeleton, muscles, male/female Reproductive system is considered. It is a good software for 3D understanding of the canine body. However, it doesn't get into much detail in terms of single structures such as veins and arteries (Lima et al., 2019; Sunol et al., 2019).

Cost of accessing: The cost for this software depends on the selected animal species, animal system or organs selected. For example, the 3D dog anatomy costs $27, 3D virtual cell biosphere costs $14, and the 3D frog anatomy costs $12.

PC specification requirements: As with the IVALA software, the 3D images in this software are animated and therefore the users' PCs must have the appropriate specifications. This means the PC should have the right processor (CPU), Graphics card (GPU) and Memory (RAM)

Recommendation: This veterinary anatomy software is relatively cheap but can be expensive cumulatively in that several packages need to be purchased in order to cover the entire veterinary anatomy curriculum. The initial investment would be relatively high but would pay dividends in the long term for institutions from least developed countries such as Zambia.

iii. IMAIOS vet-Anatomy

Description: IMAIOS vet-Anatomy is an interactive atlas of veterinary anatomy based on medical imaging. It has been created on the same framework as the e-Anatomy but dedicated to animals. This interactive atlas of the dog anatomy is organized in modules and is based on veterinary anatomy diagrams, medical images, radiographs and CT. It covers topics on general anatomy, regional anatomy, dog osteology, myology and other animal body systems.

Cost of accessing: The IMAIOS website provides some free access to certain modules while others are charged at a premium.

PC specification requirements: This software does not have animations and therefore PCs with basic processors and RAM can handle the images.

Recommendations: This software is relatively cheap in that it provides some modules for free. Institutions from least developed countries could make use of the free modules and only purchase other relevant modules.

Biochemistry

Online teaching of Biochemistry can be done with the help of animation. Animation may be very difficult to create even more so during abrupt moving of courses online as a response to pandemics like has been experienced after COVID-19 outbreak. A quick solution would be to consider the "borrow and adopt" concept (https://www.asbmb.org/education/online-teaching/course-content) which should be very helpful to supplement online interactive lectures. Advanced Biochemistry offers tools for molecular visualisation and modelling. Some of the well-known tools are PyMol (https://pymol.org), PHYRE

(http://www.sbg.bio.ic.ac.uk/servers/phyre2/html/page.cgi?id=index) and Chimera (http://www.cgl.ucsf.edu/chimera/index.html). Although these tools may not be used directly in delivery of undergraduate biochemistry, they could be very useful in creation of demonstration material that can stimulate student interest thereby enhancing subject content comprehension. Virtual Biochemistry laboratories forms the best option to teach practical biochemistry. Some of these resources (Laboratory videos and Virtual laboratories - both open access), by subscription and commercial can be accessed through. https://www.asbmb.org/education/online-teaching/online-lab-work.

4. Discussion

Effect of the covid-19 pandemic on university education

Since the outbreak and spread of the COVID-19 pandemic, several countries have instituted travel restrictions including closure of educational institutions in order to fight the pandemic. The higher education systems have been negatively impacted by the COVID-19 pandemic. The University of Zambia, like many other institutions, has moved rapidly to transition various courses and programs from face-to-face to online delivery mode (Sahu, 2020; Gewin, 2020; Lau et al., 2020). The two main E-learning platforms (Astria and MOODLE) used by UNZA are currently adequate for delivering lectures in most programs of the University. However, these two platforms may not be entirely adequate for delivering practical-based courses such as veterinary anatomy and biochemistry.

Our viewpoint has offered some guidance to lecturers and students of veterinary anatomy and biochemistry on how they can enhance the teaching and learning of practical veterinary anatomy and biochemistry, respectively.

Several options exist for delivery of theoretical components of courses. However dedicated online learning for course practical components that would allow student physical real-life experience is not possible. This has called for moving the face-to-face practical sessions to establishment of virtual laboratories or something similar (Chandrasekaran, 2020). Teaching and learning practical Biochemistry and veterinary anatomy is challenging (Ortiz, P. A. 2020) and requires a lot of preparation time on the part of the academic staff. The abruptness with which institutions have had to shift from face-to-face teaching to online teaching due to COVID-19 requires rapid response in putting together practical sessions in the short term. This can be achieved by using various sources of materials online. No one website may provide all the practical experiments needed for a particular curriculum. While getting organised to create practical content or material, it is important to consider the "borrow and adopt" concept. (https://www.asbmb.org/education/online-teaching/course-content). Therefore, there is need to search widely to get a good collection of all the practicals that may go with the lessons as prescribed by the curriculum. Some useful online resources are hosted by the American Society for biochemistry website and they are of free access. The site gives a variety of recommended virtual laboratories and simulations and their links. The listed links would have material of different practical material on different topics. It is a good site for both practicals and theory material (https://www.asbmb.org/education/online-teaching/online-lab-work; https://www.ivalalearn.com/). Another good online source for practicals are virtual demonstration videos (Chick et al., 2020; https://easy-anatomy.com/) from various sources and hosted on various video sharing websites, among them is YouTube. Virtual laboratory demonstration videos may not deliver as per the usual experimental practicals, however, it is important to mention to students what they should look out for in the video. It is important to note that virtual laboratory demonstration videos have been indicated to increase student comprehension of laboratory techniques at undergraduate level (Maldarelli, et al., 2009). The other alternative for conducting practicals include use of dry laboratory practicals. Dry laboratory practicals may be even more time consuming as every necessary detail has to be described to the student for them to understand a single practical/experiment. The dry lab or adopted practical video should be followed by a set of questions that the student can answer with a bit of research and then write a report based on the results that are given for the dry laboratory practical or video. For this to be effective, students could be encouraged to form discussion groups or made to work in virtual groups (Chandrasekaran. 2020). Dry laboratory reports could contribute towards student continuous assessment.

Online Assessments

Maintenance of academic integrity is perhaps the biggest challenge for institutions that may have abruptly moved courses online due to the outbreak of the COVID-19 pandemic. The Learning Management System (LMS) offer features that allow for assessment. However, monitoring of such assessment to ensure academic integrity becomes a challenge. While the LMS could be made to temporarily suspend student access to course material for example during administration of a test, it does not stop the student from accessing other sources of such material from the web. This is especially the problem that may be faced during administration of tests. This then calls for innovation on the part of the lecturer when setting up questions and determining what the test is supposed to assess the student on. Written assignments may not prove to be very difficult to administer while maintaining academic integrity so long the institutions implement strict plagiarism guidelines. Online assessment using LMS comes with tools for such activities with capabilities for plagiarism check, for example Blackboard does offer "SafeAssign" which checks for plagiarism. For LMS without the capabilities of plagiarism check, use of external plagiarism software becomes the option in maintaining academic integrity (Ledwith and Rísquez, 2008). Some of the external sources of plagiarism

software like Word-CHECK, Turnitin, WcopyFind,My Drop Box, EVE (Ledwith and Rísquez, 2008) and Thenticate (www.ithenticate.com) could be considered. However, most external plagiarism software comes with a cost.

Online examinations

Veterinary anatomy and biochemistry online examinations will face the challenge of students not being able to use illustrations and as a result most questions will be formulated in such a way that students are not obliged to give illustrations in answering questions. This limits the level of examination. If illustrations are to be incorporated in examinations, the student will be required to know how to use structure (chemical and anatomical) drawing software and which means these software have to have extensions within the LMS or be integral parts of LMS. With limited time within which examinations have to be administered for a start following COVID-19 outbreak, examination questions may have to be modified from the traditional ways that have existed before. In short, questions will have to require students to give descriptive answers without illustrations. The power of illustrations cannot be overemphasized as they have the ability to reduce the space required for a description that would need pages and pages to express (Perkel, 2020). In this way illustrations may also help students to manage time during examinations. Moreover, student computer literacy level which would allow them to process words effectively coupled with lack of past experience in using online tools (Miflih, et al., 2020) could be a disadvantage due to loss of time resulting from slow typing or word processing. Considering the three hours required to adequately examine a student in Biochemistry, it may not be sufficient to conduct online examinations. This is due to various reasons among them slow internet speed in different parts of the country as well as the server speed hosting examinations. This may affect the web page loading times and hence gadget response time. Therefore, a little more time may have to be added to the traditional three hours. Alternatively, examination paper question load could be reduced to maintain the traditional examination time. However, this may compromise the course material to be examined on. This also calls in question whether students will be fully assessed. Perhaps the biggest challenge will be, as the cases may be for all examinable courses, integrity of the online Veterinary Anatomy and Biochemistry examinations without physical invigilation. In the absence of physical invigilation for all courses, proctoring software exists. Commercial softwares like ProctorU (https://www.proctoru.com/), Mettl (https://mettl.com/) and LockLizard (https://www.locklizard.com/) can be considered for use to achieve academic integrity. ProctorU and Mettl can be integrated into LMS. However, these proctoring software are very expensive and can charge per examination. It would be then important to restrict use of such facilities to examinations and not continuous assessment tests (Procko et al., 2020), although currently Mettl has a COVID-19 free trial. Although proctoring software may offer some relief in maintaining academic integrity, it has been demonstrated that students taking unproctored online examinations performed 10 - 20 % better than those that took proctored online examination. This was attributed mainly to cheating and anxiety, attributes that are already known to exist in classical classroom examination with physical invigilation (Daffinand Jones, 2018), although, these reasons for poor performance were dispelled in an earlier study that reported significant variation in examination performance results (Hollister, and Berenson, 2009). Therefore, arguably online examination proctoring may affect student performance in online examinations, especially that some students may also be suffering from COVID-19 related anxiety resulting from sudden shift to learning and taking examinations online (Cao et al., 2020).

5. Conclusion

As universities move to online based teaching from what has been discussed, there is a need for institutions to quickly revise their budgets and invest in reliable though expensive ways of administering assignments, tests and examinations to maintain academic integrity. The initial setup for most requisites for online teaching will be very expensive.

Theoretical components can generally be easily delivered online albeit reduced contact hours per session compared to classical classroom teaching, bearing in mind that online interactive lectures are recommended to last atmost an hour. Ultimately, academic calendars may have to be altered to allow effective delivery of sufficient examinable course material in a specified period of time. This should also take into account time required to prepare course material for online teaching.

Faculties should deliberately draw up best possible ways or guidelines for teaching courses online and this information should be made available to all staff rather than leave each academic to themselves to devise methods of delivering content online. Therefore, adaptation of courses to online teaching should not be done at the expense of maintaining academic integrity (Wong, 2020)

The issue of teaching Veterinary Anatomy and Biochemistry requiring ways of delivery practicals to students needs serious consideration because without practicals such courses may never be appreciated by the students. This is due to the loss of hands-on experience in handling live animals, cadavers, apparatus and reagents, and reagent constitution, skills required to be learned by those who aspire to study science beyond bachelor's stage. Learning online will definitely have an effect on the examination performance by students due to various challenges encountered during adaptation to new ways of learning. Sudden shift from classical way of learning coupled with possible psychological effects of the pandemic (Ahmedet al., 2020; Cao et al., 2020) will potentially erode student confidence as performance is related to how confident the student is with the material learnt (Ahmed et al., 2020). There is more to worry for students disadvantaged both financially and geographical location especially in third world countries. The nature of

Veterinary Anatomy and Biochemistry will require students to stay online longer than usual for them to appreciate most of the concepts introduced to them. Therefore, ways and means should be devised to increase internet connectivity and accessibility particularly in rural areas.

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