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A Review of Some Innovative Teaching Concepts and Methods Used in the Field of Veterinary Medical Education

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Abstract

Ongoing global developments affecting knowledge generation, information expansion, societal changes, and the changes in the practice of the veterinary medical profession provoke new expectations, and consequently a serious change in education and training. Veterinary medical education must respond to these new challenges, and is expected to make veterinary medical practice safer and better. In this paper we reviewed some of the innovative teaching concepts, methods, and tools which are currently known in the field of veterinary medical education, and the results they have had in a real veterinary medical teaching environment. To improve the teaching of veterinary medicine, several innovative educational/learning concepts and methods were employed, modified, developed, and applied. This study reports on the major new methods and concepts, describe their principles, outline the results of testing and applications in real-life circumstances, and describe their advantages and disadvantages related to veterinary medical teaching, and students' attitudes towards them. In addition, this paper briefly introduces instructional design as the main factor that must be re-evaluated, and explains why learning outcomes must be developed and assessed to take advantage of innovative concepts and methods in teaching and curricula design. The study proposes that a combination of these innovative teaching methods is expected to have better learning outcomes needed in the field of veterinary medical education. Recommendations, including integration in the curriculum of team-based learning, peer instruction, and service learning, were put forward in this paper for consideration of all concerned.

Keywords: Veterinary medicine education; Innovative teaching; Distance learning; Teaching concepts; Concept mapping; Web-based education; Interactive learning; Interactive classrooms; Students' performance; Learning environments

Introduction

Veterinary medical education has been facing new challenges regarding education and preparation of job-ready veterinarians. Efforts for curriculum revisions have been underway for a few years. Aided by the expansion of information technology and its application, professional veterinary medical information is rapidly expanding in a way that it can no longer be studiously gathered and memorized. In addition, students belong to the new, "digital native" [1,2] generation (the so-called generation Y2), and the new social, professional, and economic requirements and the expectation that graduates to have certain competencies. All these factors have forced a change in the definition of knowledge, and new concepts of teaching, and delivery of the curriculum have been developed. Knowing is not any more a mere product of rote memorization but is the result of the process of meaningful learning [3,4]. An effective learning environment should be created within the frames of a new instructional design where the facilitation of learning takes the place of knowledge providing [5]. However, effective learning is more than the result of proper and quality teaching. An effective learning environment must include active interactions among faculty and students, and students their peers. Harvard experience with peer instruction proved to be valuable for learning of basic sciences [6]. Case-based learning helps students integrate basic medical sciences concepts and apply the information to solve clinical cases.

Recent educational challenges are stimulating the evolution of new, creative, innovative, dynamic teaching strategies, and methods and tools. The new educational approach focuses on informing, engaging, and stimulating students to create their own innovations, while it recognizes the diversity of students and their individual ways of thinking and learning [4]. Teaching and learning must encourage students' engagement in the learning process, autonomy, competence, and learning gains. Veterinary medical education is expected to comply with the new requirements evolving from the above changes [7] and the requirement for critical competencies needed for the practice of veterinary medicine. The competencies include problem-

solving, critical thinking, team work, communication, that can be nurtured by appropriate pedagogical practices. In the spirit of global education reform, many innovative teaching concepts and methods that have appeared in teaching veterinary medicine were primarily adopted from other disciplines. However, it remains to be further documented which tools can bring effective learning into the veterinary medical instruction. This is in line with the 2011 North American Veterinary Education Consortium roadmap where "teaching and learning strategies "were ranked first with regards to future research [3]. Our goal for this paper was to review the innovative teaching concepts and methods that are currently known to the field of veterinary medical education, and what results they have had in a real veterinary medical teaching environment. Our intent was also to provide specific recommendations.

Discussion

Problem-Based Learning

The problem-based learning (PBL) method mimics real-life situations to enhance and stimulate learning, knowledge integration, lifelong learning skills, cognitive, metacognitive, and personal development [8,9] and team work. Furthermore, PBL focuses on the development of problem-solving skills, team-building, self-directed and independent learning, communication, interpersonal skills, critical thinking, activation of prior solid knowledge, holistic approach, and self- and peer-assessment abilities [9,10]. In our College, PBL is the basis of Integration and Application courses, where students spend 2-3 weeks on a real clinical case. The ides is to help students understand how the knowledge of anatomy, physiology, pharmacology, pathology, and clinical pathology is integrated and used to come up with the correct diagnosis and treatment of a case.

PBL, in addition to problem solving, also encourages awareness, planning, stress management, reasoning, self-assessment, personal learning preference, creativity, time management. It enrages defining real problems, extending experience, decision making, group and leadership skills, coping with conflicts, and empathy [8]. It also promotes team work, communication, information literacy and life-long learning. More importantly many of the above skills are essential for everyday practice [11]. PBL aims to develop deep and long learning through higher-order thinking [9]. It was emphasized [12] that PBL is not "a mere teaching technique but a total approach to education that involves problem design, PBL curriculum development, PBL tutorials, problem-based learning compatible assessments, developing students' knowledge and capabilities, and is underpinned by the philosophy of PBL." An integrative view of innovative teaching methods can be clearly seen in suggestions of some investigators [13] for the name of PBL: "student-centered, problem based, inquiry-based, integrated, collaborative, and reiterative, learning". However, one must separate PBL and problem-solving learning as the latter focuses on problems in the learning process, while PBL is a well-described system of structures and procedures that were first systematized as follows [8]:

a. Students are responsible for their learning.

b. The structure of the problem should allow free inquiry, should stimulate, contextualize, and integrate learning.

c. Learning is multidisciplinary and integrated.

d. Students` discussions must be based on collaboration and faculty instructors should facilitate it.

e. Students must apply previous knowledge.

f. Self- and peer-assessment is integrated into the learning process.

g. PBL tasks should mimic the real world.

h. Assessment methods should measure the progress toward meeting the goals of PBL.

i. The curriculum should be based on the PBL principles (cumulative, integrated, progressive, and consistent).

Further, PBL tutorial process was described in eight points [14]: Exploring of the problem; identification of previous knowledge; identification of gaps in the knowledge; prioritization of the learning needs; engaging in a self-directed search for knowledge; returning to the group and sharing of the new knowledge; application of the knowledge; and assessment of the learning process and result. Attention must be called to the problem as a provoker of a so-called liminal space, or time between 'what was' and 'what is next', should be considered when creating problems for PBL [12]. Also, it is emphasized that PBL problems should not be mere "hooks to hang new knowledge on" but they should have the maximal potential to enhance PBL goals [12]. On the other hand, the term "edge of chaos" is a good description for learning and the flow of experience in PBL. In this state of learning/knowledge, creativity, learning, and flow are interacting under agreed upon and frequently reviewed basic rules within the PBL team [15].

PBL was recommended for introduction into the veterinary curriculum, parallel with other active teaching methods such as interactive lectures and seminar sessions [8]. In addition, students must develop their own learning issues and they should be able to find an answer to the questions and identify missing information [16]. One must note that in some cases [16] PBL learners scored less points on a traditional, knowledge testing examination, such as the Part I National Board Medical Examination, than learners from the traditional systems. Two major concerns about PBL were expressed [17]: the time PBL requires from the faculty staff who serve as tutors, and the PBL's efficiency in disseminating large materials in relatively short time frames.

Interestingly, PBL not only exists as a part of veterinary courses or as pilot studies, but there are veterinary schools, such as Purdue University in the USA, that have integrated PBL in their professional curriculum, and used it for years in its

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Integration and Application courses. Further, at the University of Nottingham's School of Veterinary Medicine and Science, 20-30% of the "total teaching delivery" is presented in the form of PBL [18]. Moreover, the College of Veterinary Medicine at Western University of Health Sciences designed an admission process that aims at selecting "students who will succeed in a student-centered learning environment" [19] and uses PBL in all their courses.

PBL and Second Life

Evaluating a Second Life Problem-Based Learning (PBL) demonstrator project, it was concluded that in Second Life, eight information- or avatar driven scenarios were designed for paramedic and healthcare management education. Students valued the realism and easiness of the scenarios that were more authentic than classroom- based ones [11].

Problem-Based Writing with Peer-Review (PW-PR)

Although scientific literacy is important, students have only a few opportunities in science-based curriculum to practice scientific writing [20]. Problem-based writing with peer-review (PW-PR) enhances reasoning and therefore reveals the cognitive structure of a physiological problem [21]. The importance of both the subject matter and the organization of the content in meaningful learning must emphasized [22]. More importantly, PW-PR does not replace didactic lectures directly and it is more helpful for motivated students. PW-PR helps in solving complex or integrative problems, synthesizing, and developing combinatory skills, and the lack of all these factors can result in low scoring on exams. The students have found PW-PR an effective learning tool [21]. Use of reflections as assignments in the veterinary courses can enhance problem-based writing.

Self-Directed Learning (SDL)

SDL, which gives the student the choice to take charge of their own learning process (autonomy), has its roots in adult education [23]. Veterinary students are exposed to SDL methods to mimic future clinical experiences. For successful SDL, several skills must be developed: information literacy, time management, evidence-based veterinary practice, and self-assessment. The interdisciplinary approach of SDL is believed to increase the students` deep learning, critical thinking, and interdisciplinary problem-solving abilities [16].

However, in the development of SDL the following two factors are quoted because they are dominant [23]:

i. "The student's feelings of being in charge and having a genuine impact on the learning situations are crucial for their desire to take responsibility.

ii. Feelings of being in charge are connected to understanding the demands of the learning context, experiences of managing and getting feedback."

SDL can be developed within PBL environment. Six competencies that are essential to be self-directed in PBL were identified [16,23]: Self-assessment of learning gaps, evaluation of self and others, reflection, information management, critical thinking, and critical appraisal. When learning in a self-directed way, students must be thinking in a similar way to their instructors; they must identify what, how, why, and for what reason to learn [22].

Portfolio Building in SDL

An important component of the SDL concept is the portfolio building. A portfolio is basically "a collection of documents linked to a common theme" [24]. Portfolio assessment is spreading in veterinary medical education. Portfolios are usually built up by students to include proof of their experiences, such as demonstrating their contribution to a team project etc. Portfolios can indicate the students' commitment, attitude and reflective skills as well as the gaps in their knowledge and experience. In addition, portfolios help students think in a holistic way, record their learning and implant the need for life-long learning, plan learning and career, feel the ownership of knowledge, encourage in SDL, and check learning outcomes [24].

Concept Mapping

Concepts maps were originally developed by Joseph Novak at Cornell University where they were examining children's knowledge and understanding of science concepts [25,26]. A concept map is a "graphic, hierarchically-arranged knowledge representation that reflects the content of an individual's semantic long-term memory" [24]. Concept maps require recalling of prior knowledge, organization of the prior and new knowledge, identifying relationships, and discovering the hierarchy of the concepts and examples. In addition, concept maps can be used for assessment and often reveal students' misconceptions [26]. The correlation between Purdue University veterinary technology students' use of concept maps and their scoring on exams were examined [25]. A positive correlation was found between students` scores on their concept maps and on their exams. However, the results did not indicate a direct cause-and-effect relationship between using concept maps as a learning tool and performing well on the exams. As for the students` attitude, most students disliked building a concept map but they admitted that concept maps were helpful for learning Physiology [26]. When concept mapping assignments were introduced into the Physiology for Veterinary Technicians course at Purdue University. Students' view was like what has been reported for freshmen DVM students [25]. When used as assignments, concept maps helped in identifying misconceptions and understanding of some key concepts in physiology. This information was used by the instructor to go over the concepts and clarify the misconceptions.

Distance Learning and Web-Based Instruction

Distance learning (DL) is thought to have started in the United States in 1890 when the University of Chicago was founded. One of the departments of the new university was the University Extension department in which correspondence studies were included [27]. DL makes learning independent of

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the geographical location and time [28]. DL has basically two types of modes of delivery: synchronous or asynchronous. There are several tools that are applied in DL such as e-conferencing (Webinars: video-, audio, collaborative conferences), course management systems (CMS), discussion forums and their combination [27]. Programmed instructions, teacher-led instruction, self-instructional textbooks, CD-ROMs, portfolios, computer-based training, interactive multimedia, electronic textbooks, Web materials, e-mails, instant messaging, Skype, Facebook were also used for DL [28-32]. Although there is progress in DL delivery, still many educational challenges need to be addressed in order to deliver interactive veterinary medical content through online distance education [33]. However, some [34] argue that DL is not simply about overtaking physical distance, and list "other distances" such as generation gaps, distance between developed and undeveloped nations and regions, technology gaps or e-learning, and the gap between educational supply and demand. On the other hand, building big means mass customization, i.e. the new system must consist of the appropriate people, materials, content, and technology for everybody. Mass customization, for example, can come from mass contribution, by adding metadata, wikis and blogs to education [34].

Web-Based Learning

A good example of web-based learning (WBL) are the online course materials that are widely used in most Western universities. However, WBL is not a homogeneous cluster of tools due to significant variations in configuration, instructional methods, presentation, and blending. Two hundred sixty-six articles on WBL were analyzed; the analysis have shown that most WBL material contains static written text, multimedia, and links to online resources. The most widespread instructional methods are patient cases, self-assessment questions, and feedback. For a more effective presentation, audio, animations, and hyperlinks were applied. Approximately 25% of the courses were blended. Blended courses use both face-to-face instruction and replace some of lectures by web-based online learning. On the other hand, web-based online interactive content with learning objects such as drag and drop, roll-over images animations, case-based learning, videos, self-assessment quizzes has been successfully used for teaching veterinary physiology [28].

Computer Aided Learning / Computer-based Learning

Computer aided learning (CAL) results from the interaction of the student and the computer. CAL can be based on electronic textbooks, multimedia materials, screen-based simulations, or virtual reality systems. A simulation is defined as "the artificial replication of sufficient elements of a real-world domain to achieve a specified goal" [35]. A simulation is never directly a copy of the real-world but a series of real-life situations combined with immediate feedback, decisions, and actions. To be able to mimic real-life, CAL simulations (or: Virtual-learning Environments) [35] must have high fidelity and exactness [36]. CAL also includes the application of so-called reusable learning objects (RLO) that is digital, flexible resources that can be reused to support personalized learning [35].

Two different CDs were tested, a case-based International Animal Health CD, and a parasite database, in seven veterinary schools/colleges [37]. Students received well the computer-aided instruction programs; the CDs proved to be effective teaching tools. However, as the authors mentioned, that the material on the CDs was being transferred to interactive websites to enhance distance learning [37]. One example is the CAL package made by the Computer-aided Learning in Veterinary Education Consortium (CLIVE, UK) that has been used in veterinary schools and practices for more than decade [32]. Another group of scientists used the so-called virtual ventilator computer simulation to test CAL in teaching veterinary anesthesia. Students found the simulation program to be user-friendly and easy to understand, and they said that the simulation helped them in understanding the major concepts in ventilation [36]. However, students found that simulation did not help them to feel comfortable in the real-life situation. When standing next to an anesthetized living animal, students did not connect the simulation and a patient. Students would use the simulation for clearing up their questions and misconceptions, because the simulation was portable, independent from space and time, allowed repetition and solo learning, and provided feedback [36].

On the other hand, when digital video clips in blood circulatory laboratories were tested [38], it was found that video clips were as effective as using microscopes and a living organism as regards learning about blood circulation. However, students using microscopes had a more positive perception of the experiment than their video-watching counterparts [38]. Veterinary students gave overall high ratings for computer-based canine osteology program (COP) for being more capable to assimilate anatomical information, for the realistic images and their dynamic labeling. The cognitive load caused by COP was less than traditional materials. However, "students' achievement scores" were statistically the same in groups using COP or paper-based materials [39]. CAL can offer a solution to the technical problems related to use of multimedia in teaching veterinary sciences beyond the lecture. These problems can be associated with images (storing, cataloging, retrieving, sharing, tracking of changes, updating). The Faculty of Veterinary Science at the University of Sydney developed a database system called "Online Library of Images for Veterinary Education" (OLIVER) to overcome the above mentioned problems [40]. The researcher concluded that OLIVER could be either a direct learning resource or it could be linked into other web-based teaching resources such as WebCT [40] or any other web-based course management system.

The use of CAL is getting more and more plausible with the spreading of tablet computers. Tablet computers can supplant traditional textbooks and lecture notes. Students can not only

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read and print out the materials but they can annotate materials highlighting what they found important etc. In other words, students can now do everything on tablet computers as they can on papers. Currently, the life of the battery remains a limitation to the usage of tablet computers [41,42].

Cooperative Learning / Group learning / Collaborative Learning

Cooperative learning (CL), also known as group learning or collaborative earning, where students in small groups help each other to learn. CL has been studied for a long time and has been found to enhance students` achievements due to the significant variations in configuration, instructional methods, presentation, and blending [43-45]. In particular students' "life skills," teamwork, communication, decision making, socialization skills, case analysis, reasoning skills, clinical skills were improved [44,46]. When students' attitude toward CL was evaluated at the University of Glasgow, it was found that CL was effective, but the students did not absolutely recognize the advantages of teamwork and they found deficiencies in the guidance provided by the facilitators [45].

The results of an experiment with veterinary students about collaborative, case-based learning [47] showed that only one third of the students mentioned that collaborative learning had positive learning outcomes for them. This was in accordance with previous studies that documented that veterinary students prefer individual learning and the directions provided by their teachers. However, students could appreciate group activity if the activities are facilitated well by coaches or tutors. In addition, students mentioned that the comfortable and supportive/fearless learning atmosphere helped their learning. The critical point was whether all group members wanted to share their knowledge, contribute to the discussions, ask a question or provide an answer. The authors suggested that friendship between the group members does not directly affected meaningful learning rather it was the affective part of learning [47]. Group learning and group project work can increase interaction and successful work between students from different cultural backgrounds [48].

Web based applications (e.g. Wikipedia, Connexons, Cochrane Collaboration, Wikis) offer a global "meeting place" that can be a starting point of real collaboration and of the further development of collective knowledge for common good [49]. It remains to be investigated whether online collaboration benefit learning of veterinary medical sciences. In addition, the role of social media in collaborative learning of veterinary medical sciences remains to be investigated.

Inter-Professional Education

Inter-professional education (IPE) takes place when "two or more professions learn with, from and about each other to improve collaboration and the quality of care"[50]. IPE encourages development of not only strictly professional skills but teamwork, communication, an understanding of the roles of different professions, and leadership [51]. An interesting experiment [52] was conducted with medical and veterinary medical students to find out if inter-professional education would help sharing the knowledge of skills, personal confidence, professional and personal development, respect between professions, and reflective practice. Within the short program, medical students visited the nearby veterinary school to learn "basic surgical skills from the veterinary medical students" instead of attending the medical clinical campus located far away. Their results were very encouraging but not all positive. While medical students reported positive effects, veterinary medical students` attitude towards inter-disciplinary collaboration was less positive after the collaboration than before [52].

On the other hand, two interventions were used in a pilot study [51] on IPE between veterinary and veterinary nursing students for promoting the understanding of professional roles and Emergency-Case Role Play to enhance teamwork and communication [46]. The outcome of the study was positive in that most of the students involved enjoyed IPE, teamwork, and collaboration was increased between the two professions, while professional isolation and hierarchical views were decreased 51.

Research-Led Teaching and Learning

Most universities policy statements note that research (discovery) and teaching (learning) have a unique and fundamental relationship. Research is beneficial to teaching, and researchers are believed to have the potential to create a high-quality and competitive learning environment and experience that would enhance learning outcomes. Although students acknowledge the value and idea of the research university, most personally feel excluded from the research community, and have a poor understanding of the nature of academic work [53].

It has been suggested [53] that there are five principal modes of research-led teaching and learning: Integrating relevant and recent research in courses; revealing research- knowledge relationship; emphasizing research skills in undergraduate courses; establishing opportunities for acquiring research skills in dedicated units; and integrating research activities or projects in courses. The Department of Physiology at the University of Melbourne, a research university, developed a teaching plan to introduce research-led learning to second-year students in physiology. They combined practical classes or workshop discussions, active lectures, and e-learning activities. During the 1st semester of the course, students learned experimental design, physiology and investigative skills. Then in the 2nd semester, students had to carry out a group project and to write an article-like manuscript. This research-led learning was facilitated by an electronic feedback system. It was concluded that the new tool enhanced interest, motivation, and exam performance of the students [53,54]. Further, at the Purdue University Center for Authentic Science Practice in Education (CASPiE), a "Genetic Analysis of Adaptation to Osmotic Stress in Salmonella" module involved graduate students in isolating Salmonella mutants for

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a certain protein. Students were guided in experimental design, basic laboratory skills, data interpretation, teamwork, literature overview, written and oral presentation, and writing scientific papers. Students thus could experience the process of discovery, while their confidence and interest were improved [55].

Evidence-Based Veterinary Medicine

Evidence-based Veterinary Medicine (EBVM) integrates research evidence, clinical expertise and manager values. The main four steps of EBVM are [56]: Step 1: Ask relevant and answerable clinical questions with respect to PICO (Patient or Problem, Intervention, Comparison, and Outcome); step 2: Find the best evidence to answer the question; step 3: Evaluate the validity, impact, and applicability of the evidence critically; step 4: Integrate the evaluation with clinical expertise, patient's biology, values, and circumstances. It was concluded that the suitable assessment system format for EBVM is PICO [16]. On the other hand, it was asserted that an appropriate information infrastructure is needed for evidence-based veterinary practice to connect to clinical research and practice; such an infrastructure exists in human medicine, however, in a much-developed form [57].

Case-Based Learning Method

For the development of an e-learning tool for establishing a so-called case-based learning method (CBLM), investigators [58] combined a data collecting system and a web interface for teaching equine orthopedics at the Faculty of Veterinary Science, University of Liverpool. The advantage of the system was that it allowed working on real patient cases. The new tool proved to be effective, but students in the e-learning group felt they had less "overall ability to have a systematic approach of radiographs" and "to interpret radiographs". Their results pointed out the importance of the face-to-face (f2f) lecturing and instructor-provided context from the students` point of view [58].

Active Learning

Active learning (AL) is "an active, interactive, self-aware process that results in meaningful, long-lasting changes – in knowledge, understanding skills, behaviors, attitudes, beliefs, opinions, and/or values – that cannot be attributed primarily to maturation" [59]. It was pointed out that active learning is essential for success in the profession [60]. Active learning can be achieved using a combination of many teaching tools, such as "reading, writing, discussion, case-based instruction, collaborative learning, computer-assisted instruction, and problem-based learning" [61]. The tools that can be used for active learning depends on the courses and stage of students in their curriculum.

Classroom Performance System (CPS)

The average attention span of adults is a maximum of 20 minutes, while new information can be recalled in 15-20 minutes. Breaks in instruction using CPS testing reduces cognitive fatigue [62]. To enhance and test active learning in large-size classes, a study [63] applied the classroom performance system (CPS) where students use hand-held wireless response pads to answer the instructor's questions. According to the study, CPS was suitable to quickly and efficiently engage the whole class into the learning process, and the students had a positive attitude towards the new system. A similar study was carried out using audience response systems (APS) [62]. We at Purdue adapted ECHO, a lecture recording system, to engage the students and their peers in answering instructor's non-graded questions on the major concepts in lecture. The questions were embedded into the instructor lecture notes and were spaced on 15 minutes intervals. Students' evaluation of classroom activity has been positive.

Peer-Assisted Learning

Peer-assisted learning (PAL) means that "people from similar social groupings who are not professional teachers help each other to learn and thereby are learning themselves by teaching" [64]. PAL was tested with a clinical skills stimulator [64]. The test was successful with students reporting improved communication and teaching skills, understanding the material, and a relaxed learning and teaching environment. However, students also identified a disadvantage and critical point in PAL - the peer tutor's knowledge or lack thereof [64].

Blended Learning and Interactive classroom

Blended Learning (BL)

The previous concepts and methods drew a clear distinction between f2f and online learning. However, these are not the only options for teaching and learning. The Sloan Consortium names the pillars (goals)of quality education: "access, student and faculty satisfaction, learning effectiveness, and cost effectiveness". To reach these goals, all educational approaches and methods can be acceptable. The combination of classical classroom learning and online learning is the so-called blended learning (BL). For example, in veterinary medical teaching, classroom activities can be combined with other media tools such as the Veterinary Information Network (VIN), International Veterinary Information Service (IVIS), WebSlide, SynchronEyes, 3D anatomy representations, Macromedia Breeze live, Macromedia Flash files, Web Picture Archiving and communication system (Web-PACS), motion analysis EVaRT software, and Noldus Observer [28,65]. Some educational researchers think that the hybrid model of online (distance) and f2f education is the optimal way for teaching and learning [30,66]. In addition, blended learning can be feasible for a wide selection of learning types and individuals [30].

Interactive Classroom (IC)

An interactive classroom (IC) is an important tool in BL. The characteristics of an interactive classroom were suggested [67]: Students are attentive and intellectually committed to the lecture; students ask questions frequently; the lecturer tries to motivate the students and make them to reach their maximum potential but expects excellence; students often prepare for the

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lecture in advance; students answer the lecturer's questions freely and thoughtfully; students are expected to attend the class and to arrive on time; students must have willingness for learning; constructive criticism must be provided by both sides; students often ask for additional material and more challenge; veterinary medical-focused concepts and principles have a priority over other details; exams are challenging and relatively difficult, including so-called open-ended questions such as essays; students may obtain copies of old exams; students are asked to pose questions at the end of a lecture.

Interactive classrooms resemble the dynamic interaction characteristic of clinical training and practice (work) environment; and have a positive impact on the students` thinking, problem-solving skills, and motivation [67].

Conclusions and Recommendations

New challenges have forced the appearance, testing, and applications of different innovative teaching concepts, methods, and tools in veterinary medical education. Major methods and their variations have been reviewed and discussed and found to be applicable in real classroom environments. However, they have advantages and disadvantages. The following factors can be listed as advantages: help in synthesizing and solving complex problems, development of combinatory skills, students' positive attitude, clearing up questions and misconceptions, and independence from space and time. Also, advanced as advantages are: immediate feedback, the possibility of repetition and solo learning, classroom environment that is conducive to learning, successful work among students from different backgrounds. Better performance on exams, more interested and motivated students, holistic thinking, help in planning learning and feeling responsible for one's knowledge, and easier engagement of students are considered important advantages. The most common factors that appeared as disadvantages of some innovations tools used in teaching were: less points scored on exams (albeit in the traditional testing system), more time and effort needed from the faculty staff, less efficiency in disseminating large materials. In addition, what was listed as disadvantages were: no direct cause and effect relationship between using a tool and performing well on the exams, negative attitude from the students' side, less manual and practical experience, and more dependence on the peers' knowledge and communication.

It is worthwhile emphasizing that that the application of all the concepts and methods reviewed in this paper are reasonable and their implementation was basically successful in teaching veterinary medicine.

Based on the above conclusions, the following recommendations are made

a. To avoid the possible drawbacks of using single methods, a combination of the different (both new/innovative and traditional/f2f) tools may lead to the optimal and desired learning outcomes.

b. Consult with colleagues who used a tool or tools before implementing in teaching the courses. This will help in overcoming students' learning bottlenecks.

c. Employ a hybrid model, such as an improved version of blended learning, in teaching veterinary medical sciences.

d. Consider using Team-based learning as an integral part of instruction of basic medical sciences. This will provide a structured way to incorporate cases that would encourage integration and application of anatomy, physiology, pharmacology, pathology, clinical pathology and epidemiology in solving clinical cases.

e. Include in the curriculum service learning elective courses that emphasize the learning rather than the service.

f. Integrate in teaching Peer Instruction that help students learn from each other. This can be done in flipped classroom setting, or as part of regular lectures at the end of- or during each lecture. Time may be reserved for 2-3 questions that each student attempts to answer alone, and then agree on an answer to the same questions as 2-3 peers.

g. Encourage in colleges of veterinary medicine/veterinary sciences, through provision of small grants, educational research that would encourage instructors to try different teaching methods/tools and evaluate and publish their findings on the effectiveness of these methods or tools in learning.

h. Encourage in basic sciences more flipped classroom education. Students should come to class prepared for applying what they have learned. Students work in teams and this promotes accountability. Flipped class rooms that use case-based learning help students with basic professional competencies: Lifelong learning, team work, communication, critical thinking, and problem solving.

i. Explore employing a method [68,69] to evaluate learning evidence when cumulative exams are used as part of performance assessment in basic medical sciences and other preclinical courses. There are several advantages noted for using cumulative final exams [68,69].

Conflict of Interest

We declare that there is no any economic or any conflict of interest exists.

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