Investigating the use and perceived effectiveness of a case-based e-learning tool in a second-year clinical medicine course at the Ontario Veterinary College

by

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ABSTRACT

INVESTIGATION OF THE USE AND PERCEIVED EFFECTIVENESS OF A CASE-BASED E-LEARNING TOOL IN A SECOND-YEAR CLINICAL MEDICINE COURSE AT THE ONTARIO VETERINARY COLLEGE

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Exposure to real-life clinical cases has been considered as the optimal manner of achieving deep learning in medical education, yet the availability of teaching cases and standardizing case exposure poses a challenge. Case-based e-learning (CBEL) has been considered a promising alternative to address these hurdles in many medical education programs, however the use and exploration of CBEL in veterinary medical education has been limited. The overall goal of this thesis was to gain insight into veterinary students’ perceptions of the use and effectiveness of a CBEL tool in a second-year clinical medicine course at the Ontario Veterinary College. Specifically, we explored changes in veterinary students’ perceived knowledge and skills, learning behaviour, and attitudes when using a CBEL tool. The results from this study indicate that CBEL may be a viable learning modality and encourages further exploration of the effectiveness and use of CBEL in veterinary medical education.
Firstly, I would like to thank Dr. Deep Khosa for your guidance and support throughout this journey. Your patience, humour, and enthusiasm has made the past few years quite enjoyable. Trusting me with this project and challenging me to constantly be better has taught me how to be a better researcher, leader, and person. I can’t thank you enough for helping me grow.

Thank you to my advisory committee members, Drs. Alice Defarges, Kerry Lissemore, and Todd Duffield. I am grateful for your continual support and effort with project planning, conducting my research, writing, and professional development. Your expertise has been extremely valuable.

Special thank you to William Sears for his statistical and programming advice throughout this work, to the Learning Enhancement Fund for providing financial support for this project, and to all the veterinary students who volunteered their time to participate in my research.

Lastly, thank you to my family and friends. Your endless encouragement and positivity has kept me motivated throughout this process. I am glad I always have you to lean on and am thrilled I can share this accomplishment with you.
STATEMENT OF WORK

Study Design

I was assisted by Dr. Deep Khosa in designing the qualitative study including and by my advisory committee (Drs. Deep Khosa, Alice Defarges, Kerry Lissemore, Todd Duffield) in designing the quantitative study. The overall study design and methodology were conceived and designed by Dr. Deep Khosa in collaboration with Dr. Alice Defarges.

Data Collection

All focus group data was collected by Michael Sawras. May Kamleh assisted in facilitating one of two focus groups. Dr. Defarges led the introduction to case-based e-learning in each Clinical Medicine II computer laboratory where data was collected. Subsequently, all quantitative data was collected by Michael Sawras.

Data Analysis

All data collected was analyzed by Michael Sawras. William Sears helped provide an introduction to SAS programming and helped create a base code for data analysis that was further developed by Michael Sawras.

Preparation of Results

The literature review, each manuscript, and discussion chapter were prepared by Michael Sawras prior to receiving edits and feedback from Dr. Khosa. Following this editing process, each chapter was sent to Drs. Alice Defarges, Kerry Lissemore, and Todd Duffield for further review.
Subsequent editing was completed by Michael Sawras prior to submission to the Journal of Veterinary Medical Education for publication of Chapters 2 and 3.

Results were presented in poster format at the International Conference on Communication in Veterinary Medicine in March 2018 and the Joint Veterinary Educator Collaborative and Primary Care Veterinary Educators Symposium in June 2018. Results were presented in oral format at the Teaching and Learning Innovations Conference in May 2018.
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<td>CAI</td>
<td>Computer-assisted instruction</td>
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<td>Case-based e-learning</td>
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<td>Case-based learning</td>
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<td>CLIVE</td>
<td>Computer-Aided Learning in Veterinary Education</td>
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<td>DVM</td>
<td>Doctor of Veterinary Medicine</td>
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<td>GBL</td>
<td>Game-based learning</td>
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<td>LMS</td>
<td>Learning management system</td>
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<td>OVC</td>
<td>Ontario Veterinary College</td>
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CHAPTER ONE

Introduction, Literature Review, Thesis Outline and Objectives
Introduction

Post-secondary education faces increased challenges and pressures to provide students with qualities such as critical thinking and teamwork, as well as the tools to carry out lifelong learning (Allenspach et al., 2008). In the context of healthcare programs of study, deep learning is also preferable as it prioritizes understanding over memorization, and is often necessary in human and veterinary medicine education (Allenspach et al., 2008; Monahan & Yew, 2002; Newble & Entwistle, 1986). Particularly, deep learning can help link theoretical knowledge to clinical application, thereby facilitating understanding of complex concepts that are typically present within clinical cases (Allenspach et al., 2008; Monahan & Yew, 2002; Newble & Entwistle, 1986).

Case-based learning (CBL) has been identified as an effective method of achieving deep learning (Thistlethwaite et al., 2012). Clinical cases typically contain multiple complex layers of information that need to be processed and understood by applying existing knowledge, while integrating new concepts. Consequently, CBL is recognised as an effective method for veterinary students to learn and has been successfully integrated in a number of subjects in veterinary medical education (Eurell et al., 1999; Fajt et al., 2009; Krockenberger et al., 2007; Patterson, 2006; Pickrell et al., 2002; Sharkey et al., 2012, 2007). CBL has been extensively researched and is widely accepted as a valuable teaching method in many clinical education programs (Beech & Domer, 2002; DeSanto-Madeya, 2007; Garvey et al., 2000; Grauer et al., 2008; Hansen et al., 2005; Hudson & Buckley, 2004; Patterson, 2006; Thistlethwaite et al., 2012).
As physical resources, limitations of space, and the availability of real-life teaching cases in educational settings are placed under greater pressures, there has been a strong demand for efficient, effective, and sustainable learning modalities. The design, implementation, and use of e-learning has been identified as a promising way forward and has been extensively researched in many healthcare education programs. Overall, case-based e-learning (CBEL) is generally accepted and valued in healthcare education as an efficient, effective and sustainable learning mode, especially when it is used in a ‘blended’ form with traditional lecture-based learning (Rowe et al., 2012; Ruiz et al., 2006). A number of related studies have been conducted in veterinary medical education including: evaluating the effect of web-based technology on faculty teaching styles in a small-group problem-based learning environment (Schoenfeld-Tacher et al., 2005); comparing teaching radiology by e-learning versus a structured tutorial (Vandeweerd et al., 2007); exploring the development of teaching cases (Allenspach et al., 2008) and design of a learning tool to house online cases (Byron et al., 2014); and the use of expert commentary and student reflection in a CBEL platform (Creevy et al., 2017).

Despite a wide range of positive findings, the use and effectiveness of CBEL in veterinary medical education has been given little attention in academic literature. Exploring the use of CBEL in veterinary medical education may help determine whether it is an appropriate learning method to help students use lecture and textbook knowledge in navigating a clinical case, and perhaps provide an effective alternative to using real life clinical cases. Articulate Storyline 2®, an e-learning tool, was used to develop online clinical cases presenting common clinical problems. Online cases were implemented in a second-year Doctor of Veterinary Medicine (DVM) clinical medicine course at the Ontario Veterinary College (OVC) to help
students apply knowledge to realistic case-based scenarios, and to assist in teaching a methodical approach to a clinical case. Particularly, students' perceptions and attitudes to CBEL, and its effectiveness in facilitating understanding of clinical case material was evaluated.

The following literature review describes the use of case-based learning, e-learning, and case-based e-learning in human and veterinary medical education. The use of The Kirkpatrick Model for evaluating training programs as well as the e-learning development software Articulate Storyline 2® are also explained and articulated. This chapter concludes with an overview of this thesis including overall thesis objectives.

Literature Review

1.1 E-Learning

The Internet has become an important manner in which resources for both research and learning can be made available to teachers and learners in an effort to obtain and disseminate information (Hartshorne & Ajjan, 2009). With the increased use of the Internet has come an increase in technology-based learning materials and methods used in education and training programs. As a result of many educational advances, the definition of e-learning has long been debated. A common and accepted definition has been difficult to agree upon, with many researchers concluding that a commonly acceptable definition does not exist (Arkorful & Abaidoo, 2014). To complicate matters, e-learning may also be known as web-based learning, online learning, distributed learning, computer-assisted instruction (CAI), and Internet-based learning (Ward et al., 2001).
Broadly, e-learning can be defined by any learning that is enabled or delivered electronically (Abbad et al., 2009). Most e-learning definitions, however, tend to be more specific and quite often reflect the interests and specializations of the researchers disseminating them (Arkorful & Abaidoo, 2014). Welsh et al. (2003) defines e-learning as the use of computer network technology, primarily over an intranet or through the Internet, to deliver information and instruction to individuals. Guri-Rosenblit (2005) takes a technological approach and defines e-learning as the use of electronic media for a variety of learning purposes that range from an additional resource in a classroom to substitution of human encounters with online interaction. Ellis et al. (2009) provide an educational-paradigm-oriented definition indicating that e-learning is information and communication technologies used to support students to improve their learning.

Historically, there have been two common e-learning modes: distance learning and CAI (Ward et al., 2001). Distance learning refers to the use of information technology to deliver learning to students in remote locations or locations outside of a main educational delivery site (Ward et al., 2001). CAI refers to the use of computers to help deliver online or hard-copy educational materials (Ward et al., 2001).

In addition to differences in the mode of e-learning, content delivery can vary as well. Synchronous content delivery refers to real-time, instructor-led e-learning where all learners receive information simultaneously and have the ability to communicate directly with the instructor or with other learners (Ruiz et al., 2006). Asynchronous delivery refers to e-learning where learners are responsible for their own instruction and pace of learning (Ruiz et al., 2006).
They can consult instructors or other learners online or via built-in feedback systems that do not occur in real-time.

Regardless of the choice in definition or mode of e-learning, it is accepted that it encompasses a pedagogical approach that typically aspires to be flexible, engaging and learner-centred, and encourages interaction as well as collaboration and communication (Ellaway & Masters, 2008).

1.1.1 Advantages and Disadvantages of E-Learning

The manner of e-learning delivery is its most often cited advantage. Accessibility and flexibility as well as ease of access have been shown to be particular advantages of e-learning. Specifically, it provides students the ability to engage in their learning or work at any time they choose to do so (Cantarero-Villanueva et al., 2012; Ochoa & Wludyka, 2008; Welsh et al., 2003). The time at which learning occurs is often unpredictable, meaning improved access to educational materials is essential (Ward et al., 2001). In particular, ease of access benefits those who are in remote locations as this saves them from potentially time-consuming and expensive travel, and increases the availability of educational materials to potentially disadvantaged students (Al-Shorbaji et al., 2015).

Furthermore, e-learning allows students to address their own learning needs. The ability to set the pace of one’s learning provides the flexibility to learn at a speed and intensity that is comfortable for the student (Armstrong et al., 2009; Jang et al., 2005). A number of studies have concluded that e-learning may particularly benefit students who have a difficult time keeping up with traditional didactic lectures (Al-Shorbaji et al., 2015). The ability to navigate an e-learning
tool at one’s own pace has been shown to increase knowledge retention by creating a better environment to harness cognitive capability and apply previous knowledge (Peroz et al., 2009; Welsh et al., 2003). Similarly, e-learning environments allow students to tailor their learning experience to their individual needs. Individualized learning has been shown to improve and meet learning outcomes (Chodorow, 1996) and increase self-confidence in one’s abilities (Truncali et al., 2011). By reducing pressure to maintain cognitive equality with peers, students of different abilities have the opportunity to learn the same material in a manner that best supports their own personal educational preferences (Al-Shorbaji et al., 2015). In medical education, research shows that this allows students to practice clinical skills prior to experiencing real patients, allowing for repetition in a risk-free environment (Al-Shorbaji et al., 2015) and maximizing the use of their time with these patients (Vivekananda-Schmidt et al., 2005). This is also beneficial in situations where students are required to learn rare medical conditions as well as with medical specialties that students are not experienced with, providing exposure and repetition prior to experiencing them in a real clinical setting (Subramanian et al., 2012).

Due to its predominantly Internet-based nature, e-learning creates the possibility of delivering learning to a large number of students, which is typically not the case with traditional lecture-based learning (Boet et al., 2010), allowing for a decrease in the delivery cycle of educational material (Welsh et al., 2003). In addition, e-learning provides a standardized learning experience, creating consistency in knowledge delivered to students (Ochoa & Wludyka, 2008). The use of e-learning also creates an easy way to track learner activities and progress, providing organizations and institutions with more information about their learners (Welsh et al., 2003).
In order to partake in e-learning, however, one must have the necessary technological hardware and software in addition to Internet access, if required. This may come as a disadvantage to those who are in developing countries or in sites where the necessary infrastructure to support this technology is unavailable or underdeveloped (Phadtare et al., 2009). Students and teachers must also be familiar with or trained with the e-learning technology needed to deliver desired educational materials (Frith & Kee, 2003). A lack of such expertise may cause technical issues which could lead to a failure in properly delivering the intended learning outcomes or educational activity. The initial cost to implement e-learning may also be a disadvantage, especially in situations (Welsh et al., 2003) where there are no pre-existing provisions for implementing e-learning.

Despite positive findings and reactions towards the extent of student interaction while using e-learning resources, a potential lack of communication between peers as well as the inability to ask for guidance or support when there is no instructor are some of the major disadvantages to e-learning (Armstrong et al., 2009; Gerdprasert et al., 2011; Welsh et al., 2003). Examples of this include lack of student-teacher interaction (Armstrong et al., 2009; Gerdprasert et al., 2011; Phadtare et al., 2009), ability to clarify with a tutor (Armstrong et al., 2009) and in-depth group discussion (Gerdprasert et al., 2011). Students have also reported a preference for real-life discussion rather than virtual discussion (Raupach et al., 2009).

Overall, the literature reports student satisfaction with e-learning, with some students indicating a preference for it (Gerdprasert et al., 2011). However, some research indicates that e-learning was useful as a supplement to, but not a replacement for traditional learning. For example, Seabra et al. (2004) conducted a double-blind randomized controlled trial, where the
end-knowledge of students in a urology course was compared between those exposed to e-
learning and those taught with traditional lectures. Although there was no significant difference
in grades between study groups and students gave significantly positive feedback, they indicated
that an instructor was essential and could not be replaced by the e-learning tool that was used in
their class.

1.1.2 E-Learning in Medical Education

E-learning has been extensively researched in human medical education programs. The
use of computers in education drove researchers to begin exploring both non-networked e-
learning and learning delivered over the Internet or an intranet to determine its effectiveness
either independently or compared to traditional lectures.

Davis et al. (2008) conducted a randomized controlled trial evaluating the effectiveness
of the implementation of a short computer-based session in teaching evidence-based medicine to
first-year students compared to traditional lecture. Students were evaluated with pre- and post-
intervention tests, with both groups demonstrating non-different gains in knowledge. As a result,
the authors concluded that e-learning was just as effective as traditional lectures.

Ackermann et al. (2009) explored the effectiveness of an e-learning software to teach x-
ray interpretation in advanced-level medical students. Students were randomized to either an e-
learning group or a traditional learning group and instructed to identify x-rays that had
pathologies present. Time required and number of correctly identified x-rays were recorded and
compared between both groups. The e-learning group demonstrated significantly greater
efficiency, leading the authors to conclude that e-learning may be an effective teaching tool for
skills training in medical education. Glicksman et al. (2009) found similar results in their study that compared performance in nasal packing for management of epistaxis. Performance was measured between students assigned to a computer-based learning group and students learning from a text-based article, before and after interventions. Although both groups showed improvement post-intervention, the computer-based group performed significantly better. Students in this study also reported preference for computer-assisted learning compared to text-based methods.

Bains et al. (2011) explored students’ perceptions of e-learning compared to blended learning and traditional face-to-face methods in fourth-year dental students. Students reported positive perceptions to e-learning, however, blended learning was preferred, indicating that e-learning may be best used in addition to, or supplementary to traditional lecture-based learning. A similar study was completed by Armstrong et al. (2009) with fourth-year medical students. Interactive multimedia-based tutorials were compared with traditional lecture-based teaching of arterial blood gas interpretation. The e-learning group reported positive attitudes towards the multimedia-based tutorials, however, both groups indicated that a combination of the two teaching methods would be ideal. Content knowledge was also measured post-intervention, which revealed no significant difference between the e-learning and traditional learning groups.

Morgulis et al. (2012) evaluated a targeted e-learning module specifically designed for leukaemia education compared to other existing online resources. Senior medical students were allocated to either the e-learning module group or to the online resource group and tested on knowledge post-intervention. The e-learning module group performed significantly greater on the post-intervention test compared to the control group. The authors indicated that they believed
the interactivity of the module as well as feedback dialog throughout its use allowed for better integration with the curriculum and contributed towards its impact on student performance.

Overall, the medical education literature tends to point towards e-learning as an effective teaching method when compared to traditional lecture or text-based learning methods. Increase in student attitude and satisfaction towards e-learning can be seen in addition to increased performance in knowledge and skill-based assessments.

1.1.3 E-Learning in Veterinary Education

E-learning has been used in a number of capacities in veterinary education. Studies in the use of e-learning in veterinary education have generally agreed with or reported similar results when compared to research in human medical education. Prior to the development and popularization of the Internet, e-learning comprised of computer-aided learning (CAL) or computer-assisted instruction (CAI), where veterinary medicine and sciences were taught with the aid of computers. The Computer-Aided Learning in Veterinary Education (CLIVE) project originated in 1993 and was one of the first CAL initiatives created with the purpose of establishing and expanding e-learning in veterinary education (Dale et al., 2005). This project originated at the University of Edinburgh and was implemented in a number of other veterinary institutions in the UK. Included in this CAL program were tutorials, question and answer pages, digital lectures and modules. A number of other similar programs have also existed, however, they have not been as well reported.

Various studies have been completed to evaluate CAL. Dale et al. (1999) conducted a study with fourth-year students in a diagnostic imaging course and compared examination grades
pre- and post- CAL delivery (Dale et al., 1999). Students’ grades were significantly higher post-
CAL delivery, as well as compared to other classes not using CAL. Furthermore, student
acceptance of the CAL technology increased after it was established in the veterinary curriculum.
These results prompted the authors to conclude that CAL technology could replace didactic
lectures in veterinary curriculum in a supportive manner amongst other resources. Short and
McConnell (1997) similarly explained that this technology could be used not to replace an
instructor, but as an aid in order to allow instructors to be more efficient in their use of time. In
another study, Christensen (2003) concluded that 90.5% of veterinary students surveyed at the
University of Glasgow who were using CAL indicated that this technology added value to their
learning, was considered easy to use, and excellent for visual aids.

Outside of the CLIVE program, a number of studies have evaluated the use of CAL in
veterinary education. Abutarbush et al. (2006) conducted a randomized controlled trial
evaluating the effectiveness of a CAL module in comparison to traditional instruction in teaching
how to pass a nasogastric tube in a horse. The students in the CAL group performed significantly
better on a knowledge test post-intervention and demonstrated greater preparedness, however,
were slower in time-to-completion in nasogastric tube placement. Contrary to this, Norman and
Dall’Alba (2013) reported that a CAL tool used by fourth-year students in a BVSc program to
develop skills in palpation of the reproductive tract of a cow resulted in an improved rate of skill
development post-intervention when compared to pre-intervention evaluation, thereby,
improving animal welfare outcomes when students practiced on live patients.

With the advent of the Internet came a wide range of web-based e-learning applications
in a number of subjects in veterinary education. Many e-learning interventions expanded on CAL
principles and made this type of teaching method available online. Modules that were previously isolated to one computer were capable of being uploaded to the Internet and shared between networks and institutions, increasing the accessibility of resources.

Dale et al. (2005) evaluated the use of interactive online modules used for teaching veterinary molecular biology to first- and second-year students in order to determine their attitudes towards online, independent learning. First-year students comparatively rated the e-learning program highly and better than previous instruction. All students also had access to tutors in the course, which second-year students rated as less important. This led the authors to conclude that these students were comparatively more confident in using the modules. Both groups of students used the online modules in different capacities, so a true comparison could not be reached. A similar study evaluated a course format that included a new e-learning component used to teach veterinary anatomy through lecture material and modules online (Van Ginneken & Vanthournout, 2005). Likewise, students also reported positive attitude towards this new component and final exam scores increased after the learning intervention was implemented. Although results were positive, a control group was not used and the effects of other course components on final grades was not taken in to account.

Another study conducted by Winder et al. (2017) compared an online learning module to hands-on training in teaching a cautery disbudding technique for dairy calves. In this study, online learners were found to be less confident and had poorer technical skills when compared to hands-on learners. This led the authors to suggest that e-learning may not be as beneficial with regards to technical skills, which was interestingly contrary to the findings of the study discussed previously by Norman & Dall’Alba (2013). This being said, due to a relatively high success rate
for online learners, the authors in the Winder et al. study suggested that e-learning may be a beneficial tool to use in addition to hands-on training and a suitable alternative when hands-on training is not available.

Gledhill et al. (2017) conducted an international study exploring students’ self-reported use of e-learning resources to gauge access to these resources and learning methods. The study found that many students use the Internet both at school and at home for learning, using a variety of resources including Google, open educational resources and veterinary-specific platforms such as WikiVet and Merck. Students reported that these resources were very useful as supplementary material and that accessing content from other universities could be helpful for their own education. In contrast, some poor student acceptance for e-learning and computers in addition to lack of Internet access and institutional support was reported. The authors described many of these responses were from international students in underdeveloped countries which led to the conclusion that although e-learning has been widely integrated in veterinary education, a large number of developing countries are still without the resources needed to be able to do so.

While the Internet provides access to a vast range of online resources, this does not necessarily translate to effective learning opportunities. Research indicates that students have generally reported positive attitudes and satisfaction towards e-learning resources, however, e-learners need structure, the ability to work at their own pace, direction, guidance, and interaction to practice effective learning (Short et al., 2007). Case-based learning and problem-based learning are learning modalities that present cases or problems to learners in an effort to apply clinical knowledge to real-life situations. The nature of these learning modalities may satisfy the previously mentioned challenges associated with e-learning. The principles of CBL and PBL will
be discussed later in this literature review. By combining CBL or PBL with e-learning, students may be exposed to a learning method that is both accessible and efficient in nature, but still provides the structure and interaction needed to achieve effective and deeper learning.

1.1.4 Assessing E-Learning with The Kirkpatrick Model for Evaluating Training Programs

Outcome evaluation examines changes in learners’ knowledge, skills, or attitudes in order to determine the effectiveness of a program. Kirkpatrick outlined an evaluation program in the 1950’s used to determine the effectiveness of training programs and interventions (Kirkpatrick & Kirkpatrick, 2006). The Kirkpatrick Model was later adapted to healthcare education and expanded to evaluate e-learning interventions (Hamtini, 2008; Horton, 2001). This model defines four levels of evaluation based on outcome: Reaction, Learning, Behaviour, and Results (Kirkpatrick & Kirkpatrick, 2006). We have chosen to use The Kirkpatrick Model because of its wide use and acceptance in the evaluation of medical education programs, and in the implementation of new and innovative educational tools. The Kirkpatrick Model focuses on program outcomes and extends beyond learner satisfaction, meeting the needs of this project.

*Reaction* measures students’ perceptions and satisfaction with a training program in an effort to determine how accepting individuals are with the program. For a program to be effective, students must be willing to use it and must show some level of post-use approval. This being said, satisfaction alone does not measure learning, and the desired outcomes of the training program must be measured.
Learning measures changes in students’ attitudes, knowledge, or skills post-intervention. For example, the previously mentioned study by Davis et. al (2008) measuring students’ performance on a test after e-learning use would be a measure of Learning as described by Kirkpatrick.

Behaviour establishes whether changes in attitudes, knowledge, or skills are further applied in clinical practice. Kirkpatrick provides an example of a training program implemented for sales employees in an effort to improve their sales techniques. A supervisor measuring job performance and evaluating whether their employees’ sales techniques have changed post-intervention would be an example of measuring Behaviour.

Results measure the impact of an intervention beyond the level of the student. It evaluates the effect of an e-learning intervention in the context of its primary goal and reason for being implemented. Examples include improved client satisfaction or improved patient outcomes after implementing a new operating room safety protocol.

The first two levels of The Kirkpatrick Model, Reaction and Learning, are commonly evaluated as they are relatively short-term outcomes and are easy to measure. Behaviour and Results take a significantly longer time to evaluate and can become unfeasible, which explains the lack of studies that include this type of evaluation.

1.1.5 E-Learning Software Articulate Storyline 2®

Articulate Storyline 2® is an e-learning software application created by Articulate Global, Incorporated that facilitates the creation of professional-grade interactive tutorials, online courses
and e-learning programs (See & Teetor, 2014). Articulate Storyline 2® is similar in function to Adobe Captivate® in that it is a user-friendly program that allows for rapid development of e-learning programs and modules (The University of Akron - Instructional Services, 2013).

Articulate Storyline 2® includes a number of features, for example, exploratory interaction buttons, embedded audio and video (See & Teetor, 2014), timelines and process diagrams (The University of Akron - Instructional Services, 2013). The main benefit of Articulate Storyline 2® is its ability to create scenario-driven training modules, allowing users to make decisions and understand the immediate impact of those decisions (See & Teetor, 2014). Furthermore, Articulate Storyline 2® allows for the creation of simulations that explain step-by-step processes, permitting the user to watch or practice depending on the stage of their learning. In addition to this function, Articulate Storyline 2® provides the ability to create interactive and creative quizzes as well as other knowledge checking tools that allow for application of knowledge and feedback to the user (See & Teetor, 2014).

Articulate Storyline 2® has been used in a number of educational settings including veterinary medicine (Winder et al., 2017), training library employees (See & Teetor, 2014), teaching and assessment of biomedical and genetic lab techniques (Devine et al., 2015), and development of cytotechnology education e-learning modules (Mukherjee & Donnelly, 2018).

1.2 Case-Based Learning

The definition of case-based learning (CBL) has also been debated, with no one definition that has been accepted. Thistlethwaite et al. (2012) defines CBL as preparing students
for clinical practice through the use of authentic clinical cases, linking theory to practice, through the application of knowledge to the cases, using inquiry-based learning methods. Thistlethwaite continues by providing various descriptions addressing a number of aspects of the learning method described below including: the goal of CBL, the content in CBL, and the process of thinking and learning that CBL promotes.

A number of learning outcomes have been generally accepted and established in CBL. Students are subjected to real cases either before clinical practice or during rotations to expose them to variations in patient presentation and to prepare students for clinical practice (Hudson & Buckley, 2004). This also provides students with the opportunity to explore a methodical approach to a clinical case, culminating in patient diagnoses and development of a management plan (Anderson & Helberg, 2007). In addition, CBL typically aims to help students understand the underlying physiological mechanisms of various cases in relation to identifying and treating medical conditions. This allows for students to explore the whole patient as opposed to separate views of anatomical and physiological systems of the patient (Chan et al., 2008).

The content in CBL emphasizes real-life cases and practice (Bowe et al., 2009; Schoeman et al., 2009; Stewart & Gonzalez, 2006), however, can extend beyond individual patients, also including community or population cases (Bair, 1980). CBL acts as a bridge between lecture-based knowledge and real-life practice (Hakkarainen et al., 2007; Hansen et al., 2005; Hong et al., 1998), simulating the decision-making process of the workplace and giving students the ability to manage a real case (Stewart & Gonzalez, 2006). Depending on the method of delivery, CBL promotes active participation and discussion where students problem solve with support and feedback from fellow students and colleagues (Sutyak et al., 1998). In the case
that CBL is delivered as a group activity, CBL may encourage group work and cooperative learning by directing groups to work towards a common goal of applying clinical knowledge to solve a clinical case (Stewart & Gonzalez, 2006).

Others have defined CBL by comparing it to a similar yet distinctive teaching modality, problem-based learning (PBL). PBL is typically delivered in small groups, focusing on the process of learner discovery in order to stimulate problem solving, independent learning, and teamwork (Heale et al., 1988). Students are presented with a problem, often using a clinical case as a point of discussion, and instructed to explore all related areas in order to find a solution (Srinivasan et al., 2007). While practicing problem resolution, students are learning the various related topics being explored. In PBL, instructors minimally facilitate and do not guide discussion, allowing students to explore tangents that arise throughout their discussions, leading to its classification as an open inquiry approach (Srinivasan et al., 2007).

In CBL, students and instructors prepare in advance for each activity. Similar to PBL, students are presented with a case and are instructed to explore and solve it. However, in CBL, when students begin to explore tangents, instructors take on a more active facilitation role and redirect students back to a main learning objective through discussion (Srinivasan et al., 2007). Both students and instructors share the responsibility of achieving more targeted learning objectives, allowing CBL to be classified as a guided inquiry approach (Srinivasan et al., 2007).

CBL is a student-centred and problem-centred approach (Malher et al., 2009). Due to the fact that instructors act as facilitators, students are encouraged to take responsibility for their own learning. By guiding students in their learning and case-centred discussions, critical thinking is
encouraged, invoking deep learning, the most cited advantage of CBL (Garvey et al., 2000). Deep learning prioritizes understanding over memorization and simple identification of correct answers. It incorporates critical thinking and evidence-based thought, allowing for applicability of knowledge to a wide range of cases or scenarios.

1.2.1 Advantages and Disadvantages of Case-Based Learning

When discussing the advantages of CBL, PBL must be referenced. PBL was first implemented in medical schools in the 1950’s, first at the Case Western Reserve University in the United States and further innovated and adapted in the 1960’s at McMaster University in Canada (Lee & Kwan, 1997). PBL has been shown to encourage lifelong learning, simulate clinical practice, encourage curiosity, and create a broader understanding of the complex nature of medicine (Barrows, 1986; Maudsley, 1999). This being said, many argue that PBL is time-inefficient and ineffective for simulating time-constrained situations (Slavin et al., 1995). The absence of clinical direction may also deter students from being able to effectively apply clinical knowledge in practice (Roberts et al., 2005). Finally, students are unable to take advantage of expertise of instructors due to their passive role in PBL (Srinivasan et al., 2007).

CBL is a variant of PBL that may address some of the challenges PBL holds. Similar to PBL, it is thought that CBL still allows for open-ended exploration of a proposed case or problem, however, its more structured nature allows for targeted and goal-directed conversations (Srinivasan et al., 2007). CBL helps focus on the key points to a clinical case, encouraging a methodical approach to clinical problem-solving. In CBL, instructors are also allowed to correct
students should they make incorrect assumptions or decisions, thereby correcting any mistakes made (Srinivasan et al., 2007).

Although CBL has its advantages, a number of disadvantages have been cited. Some argue that the increased engagement of instructors may suppress curiosity in students due to the increased amount of information given to them while participating in CBL (Srinivasan et al., 2007). In addition to this, if faculty are not properly trained in delivering CBL, they may resort to lecturing as opposed to effectively facilitating CBL activities. The targeted nature of CBL may encourage the idea that there is a correct answer and cause students to inadvertently remove themselves from the CBL process, probing faculty and their peers in an attempt to quickly find this answer (Srinivasan et al., 2007).

In an effort to evaluate the preferences of both learning modalities, a study was completed at the University of California, Los Angeles and the University of California, Davis, exploring a shift from PBL methods to CBL methods in the medical curriculums at both schools (Srinivasan et al., 2007). Students and faculty who had experienced both learning methods throughout their degree programs were given questionnaires, with both groups heavily favouring CBL over PBL. Students preferred CBL because it allowed for fewer unfocused tangents, less unfocused exploration of clinical topics, and more opportunities for clinical application. Both groups felt that CBL offered a more efficient model of learning in a medical curriculum that is already heavily compacted.
1.2.2 Case-Based Learning in Medical Education

The use of CBL has been extensively studied in human undergraduate medical education, including in the disciplines of human medicine, nursing, pharmacy and dentistry.

Many studies explore students’ attitudes towards CBL. Hansen et al. (2005) explored student perceptions of CBL during an obstetrics and gynecology clerkship. Compared to controls, CBL students reported they were better able to understand the relationship between knowledge and clinical practice and enjoyed CBL more than the traditional lecture-based format. Hoag et al. (2005) reported similar results, as students enrolled in an immunology and serology course also rated CBL sessions higher than traditional lectures. However, student attendance was also significantly higher in CBL sessions and some of the CBL learning sessions in the study were also mandatory, meaning results may have been skewed. This study also showed that both students and instructors rated student-instructor interaction as better in CBL sessions compared to lectures. Hudson and Buckley (2004) conducted a cross sectional study with three cohorts of students and one cohort of tutors enrolled in a medical physiology course, exploring the use of CBL in the course. Students and tutors indicated that CBL created a safe environment for students to gain confidence in the knowledge and abilities before their first real patient encounters. Finally, Simonsohn and Fischer (2004) report that students participating in CBL in an internal medicine course indicated increased motivation leading to a high rate of acceptance and use.

In addition to attitudes, a number of studies explored students’ self-perceived learning and outcomes after using CBL methods. DeSanto-Madeya (2007) evaluated the implementation
of CBL in a medical-surgical course in nursing education and asked for student feedback on their learning at the end of the course. Students reported that their critical thinking and clinical decision-making skills were enhanced after using CBL and that they were able to problem-solve better. Although students also reported that they were discouraged by the amount of time needed to complete the CBL activities, overall, they demonstrated positive attitudes towards its implementation in the course. Similarly, Garvey et al. (2000) also reported favourable attitudes in dental students towards CBL being implemented in the final year of their program, with majority of students agreeing that CBL was a worthwhile switch from the previously-used PBL approach.

A number of studies attempted to evaluate student learning and changes in attitudes through the use of tests or surveys. Beech and Domer (2002) evaluated CBL in a third-year surgical clerkship with pre- and post-use knowledge tests, with students showing an increase in knowledge of physiology after CBL. Furthermore, Jamkar et al. (2006) reported comparable increases in knowledge scores in students exposed to CBL compared to others who were taught with traditional lecture-based methods in a cellular biology course. A normalized learning gain metric was used to compare learning outcomes between the students exposed to CBL compared to those who were not. CBL students exhibiting significantly higher learning gain compared to controls (Rybarczyk et al., 2007). The CBL students also showed an increased likelihood of answering questions that were found to be more challenging in nature, suggesting CBL may help develop higher order thinking skills by enhancing development of knowledge through deeper learning. In contrast, Carrero et al. (2008) studied students participating in basic life support training and found no difference in knowledge gain between CBL students and students exposed
to traditional multimedia lectures. Although both groups increased overall knowledge, students were only exposed to three cases, each for an hour, which may not be long enough to see any difference in effects. Gemmell (2007) found similar results in students enrolled in an orthopedics course, comparing one cohort where a CBL curriculum was integrated in to the course to the previous cohort without CBL. Although exam scores in both cohorts were not significantly different, other changes in the course along with differences in content were not taken in to consideration.

One study tried to explore the longer-term effects of CBL in third-year students studying obesity-related nutrition in an obstetrics and gynecology clerkship by following up with this cohort in their fourth year (Dayal et al., 2008). Students showed an increased level of knowledge over a year later, however, there was no comparison group in the study to determine any similarities or differences in a non-CBL group.

1.2.3 Case-Based Learning in Veterinary Education

CBL has been successfully implemented in a variety of veterinary medicine courses including clinical pathology (Sharkey et al., 2012, 2007), histology (Eurell et al., 1999), clinical toxicology (Pickrell et al., 2002), and pharmacology rounds (Fajt et al., 2009).

Similar to human medicine, the use of CBL has produced positive results in veterinary medicine. In a study conducted by Patterson et al. (2006) exploring an integrative case-based approach to teaching second-year students, a large majority agreed that the case discussions provided a more enjoyable learning experience and that they felt they had a deeper understanding of the course material. This being said, inconsistencies between different topics and teaching
methods caused students to express frustration, explaining that their ability to integratively approach a case was hindered. Similarly, Sharkey et al. (2007) reported increased learner confidence which was indicated by larger self-reported increases in the understanding of course material and ability to apply information along with increased feelings of preparedness for classes and examinations. Sharkey et al. then conducted a prospective cohort study in 2012 to determine whether CBL assignments could predict future academic performance and if perceptions of the effectiveness of CBL persisted throughout the curriculum. It was observed that CBL led to higher GPA and class rank in subsequent years following its use and students reported that CBL was superior to a lecture-based format with regards to learning clinical reasoning skills, retaining factual information, organizing information, communicating medical information clearly, and preparing high quality medical records. Patterson (2006) also reported increases in student self-confidence in clinical reasoning skills after using CBL in their semester. This was reinforced by faculty evaluation of these clinical reasoning skills, which also indicated improvement throughout the semester.

Furthermore, Thurman et al. (2009) explored how veterinary students learn from one another by investigating students’ perceptions on a collaborative case-based learning activity. Although only 32% of students spontaneously mentioned collaboration in their comments, over time, students became more positive towards group work and collaborative learning. Khosa, Volet and Bolton (2010) built on this study and demonstrated that although veterinary students tend to be achievement-motivated, individual learners, they can be persuaded of the benefits of collaborative learning, especially in a case-based scenario. Monahan and Yew (2002) supported this finding in their study with third-year students in a veterinary parasitology laboratory. Student
feedback was highly favourable, with the most common response being that group work helped
develop clinical understanding and that a case-based approach fostered an environment that
provided valuable clinical insights. This reinforces the notion that the potential collaborative
features of case-based learning can be valuable for student learning, especially in promoting
deeper learning.

Grauer et al. (2008) conducted a randomized controlled trial to compare traditional
lecture-based teaching and case-based teaching in third-year veterinary students. Examination
scores indicated that students performed better on high-difficulty questions after case-based
teaching compared to lecture-based teaching, however, showed no significant differences in
scores in medium- or low-difficulty questions. This may support the notion that CBL promotes
deeper learning and increased cognitive capability.

1.3 Case-Based E-Learning

Case-based e-learning (CBEL) involves an online delivery of CBL (Wheeler, 2006). The
extent of online delivery is variable. This can include creating and delivering online or electronic
cases through email or a learning management system and giving students access to these cases
to use at either pre-determined periods of time or at their own leisure (Ellaway & Masters, 2008).
CBEL is commonly delivered in a blended learning format, where students learn in traditional
didactic lectures and access cases delivered online outside of these lectures.

Garrison & Kanuka (2004) describe blended learning as the integration of online and
traditional face-to-face teaching methods to support and enhance meaningful interaction between
students, teachers and resources. Blended learning allows for greater flexibility in the teaching
and learning process (Lewin et al., 2009). Similar to e-learning, the integration of online components of instruction has been shown to overcome time and space challenges, enhance instruction of concepts or topics that are difficult to teach with a textbook, and creates the ability to reach more students (Gray & Tobin, 2010). The integration of technology and online learning into curricula creates the potential to facilitate flexible, learner-centred teaching and expand the ability for students and teachers to collaborate and communicate (Ellaway & Masters, 2008).

Blended learning has been evaluated in healthcare education, with generally positive results. Rowe, Frantz & Bozalek (2012) report that in studies evaluating the development of students’ clinical competencies after implementation of a blended learning strategy, there was generally evidence of improvement in these competencies. The authors indicated that although better grades were not always achieved, improvement was seen in clinical competencies that have been identified as important for development of practical knowledge such as reflective skills, clinical reasoning, and application of theory to practice.

In CBEL, students can work either individually or collaboratively on the cases, interacting with either solely the computer or with their peers, respectively. CBEL can also include delivery in a distance learning method. In this case, a virtual classroom is used and there is minimal to no face-to-face interaction between students and their teacher(s) (Ellaway & Masters, 2008). Students interact with each other in virtual discussion boards, chat rooms, or through email, all remotely. The teacher(s) or facilitator(s) participate(s) in their traditional role, however, online like their students (Ellaway & Masters, 2008).

CBEL traditionally appears as an interactive computer simulation of real-life clinical scenarios for the purpose of medical training, education, or assessment (Ellaway & Masters,
Typically, a structured virtual patient encounter is presented to a student where the objective is to search and interpret data or information and make clinical decisions to solve problems such as creating a problem list, determining appropriate diagnostic tests, diagnosing the patient and developing a treatment plan (Ellaway & Masters, 2008). Cases are typically presented with all steps to solving a case, from taking a patient history to developing a treatment plan and even follow-up, with some cases designed as a framework to teaching students a methodical approach to a clinical case. They are designed to push learners to engage with the material, make reasoned decisions along the way, and apply previously learned principles to the case at hand (Ellaway & Masters, 2008). Most cases also connect didactic activities or learning objectives for the purpose of applying knowledge learned in traditional lectures and promoting critical thinking and problem solving (Ellaway & Masters, 2008).

CBEL can standardize learning content and quality, facilitate active learning, and avoid the challenge of repeating simulations with real cases (Ellaway & Masters, 2008). The ability to track student usage allows one to explore learner competency at very precise moments in a case.

CBEL creates a learning environment in which cases can be tailored to any skill level and replayed on demand for learner convenience. This creates the opportunity to pace oneself, thereby reducing cognitive load (Ellaway & Masters, 2008). CBEL has been studied and evaluated in a wide range of educational programs including healthcare education and medicine.

1.3.1 Case Based E-Learning in Medical Education

CBEL has been widely studied in human undergraduate medical education and is frequently implemented in medical education programs across the world. As the use of the
Internet in education began to increase, the use of CBEL also began to increase in an effort to decrease teaching burden and increase accessibility and convenience in resources and educational materials. Many research studies were conducted to compare CBEL to traditional teaching methods in order to determine if it was an effective teaching tool and if it could replace these traditional methods.

In a study conducted by Gaupp, Korner and Fabry (2016), third-year medical students received online surveys before and after a CBEL course on patient safety. Students showed increased knowledge and attitudes towards levels of systems thinking related to patient safety after the CBEL-structured course, indicating that CBEL was an effective method of teaching the subject-matter. Contrasting results can be seen in a study by Smits et al. (2012), where the authors measured knowledge, attitudes, and satisfaction towards occupational health in medical students who were taught with CBEL methods compared to students taught with traditional text-based methods. These outcomes were measured at baseline, directly after the intervention, as well as one week and three months post intervention. There were no significant differences in satisfaction and knowledge at all measurement points and attitudes towards occupational health significantly decreased after short-term follow-up. This being said, the authors indicated that occupational health is not a popular subject with medical students, which may explain the lack of improvement seen in the study. In a differing method of CBEL delivery, a study by Taradi et al. (2005) explored CBEL in a blended-learning acid-base physiology class where didactic lectures were attended followed by delivery of online cases. Students were to work on the online cases collaboratively, with test scores and satisfaction measured and compared with a cohort of students who completed in-person versions of these cases prior to their movement online. The
online cohort scored significantly higher on the final exam in the course and showed a positive response to satisfaction with the new online method of delivery.

On a larger scale, Kolb et al. (2009) conducted an international evaluation of CBEL modules that had been developed and distributed to occupational medicine programs across Europe. Twenty-six cases were created and evaluated for perceived effectiveness by students across all centers. Students reported that it was easy to accept the use of the online cases in to their curriculum as well as a high level of interest in working with them again.

Howlett et al. (2009) explored the integration of a case-based online module in to a fifth-year medical curriculum. The authors reported that although there are significant set-up costs involved in designing and implementing the online modules, these costs drastically diminished following the initial set-up. Similar to the studies above, students reported high levels of satisfaction and articulated appreciation of the educational benefits of delivering the cases in an e-learning capacity.

Kandasamy and Fung (2009) conducted a prospective randomized controlled trial with medical students in a second-year pre-clerkship undergraduate otolaryngology course. The authors explored the effectiveness of achieving specific learning objectives related to paediatric stridor after using an Internet-based case compared to two Internet review articles. Students were randomized in to one of the two groups and tested on topic knowledge prior to and after intervention. Although both groups showed significantly higher scores post-intervention, the online case group showed a significantly higher mean post-test score when compared to the article group. The students in the article group also spent significantly more time completing
their task when compared to the online case group. Eighty-eight percent of participants indicated that they would prefer online cases compared to review articles.

Finally, Choi, Lee and Kang (2009) explored CBEL use in a lecture-oriented anaesthesiology class to determine if learning styles affect solving complex problems presented in online cases over a three-week period. Students completed a learning style survey followed by problem-solving evaluations after completing the cases. Learning styles did not significantly influence any outcome measurements or satisfaction scores and were not significantly different at any time throughout the three weeks of evaluations, leading the authors to indicate that CBEL did not lead to increased learning earlier on in any of the learning styles.

1.3.2 Case Based E-Learning in Veterinary Education

CBEL has been scarcely researched in veterinary medical education compared to other medical education programs. A handful of studies have been conducted but are generally centered around the time required to develop, implement, and support its use.

Trace et al. (2012) explored the development of student-authored cases by final-year students. Clinical case data and media was collected from various teaching hospitals and incorporated into a case template to create teaching cases that were presented at grand rounds. These cases were further refined to be used for teaching by including self-assessment points. Students reported that creating these online cases was a useful exercise and that their experience improved their approach to a clinical case. Byron et al. (2014) conducted a similar study in which a different case development tool was evaluated. The authors indicated that many online case development tools were costly, time intensive and difficult to navigate when creating cases,
which led to their pilot evaluation of Case Manager, which was deemed a low-cost, user friendly alternative. These cases were designed for senior students in a small animal internal medicine rotation. Students reported that the online tool increased their engagement with case material, improved diagnostic and problem-solving skills, and gave them exposure to a wide variety of cases that is not guaranteed in the clinic. Students also reported, that this online tool was superior to other, less interactive cases they had prior exposure to.

Schoenfeld-Tacher et al. (2005) explored how the introduction of new online cases influenced faculty teaching styles while facilitating small group PBL sessions. Their research indicated that there was no direct evidence to suggest that the use of the online cases affected teaching behaviour, but that throughout the course of the semester, instructors generally showed moderate increase in comfort using technology in their classes and that individual teaching styles remained stable throughout the course of the semester.

Allenspach et al. (2008) conducted a study evaluating deep learning in third-year students using interactive online clinical cases. Students reported that they were able to work independent of a tutor available to them, the cases were realistic in nature, stimulated students’ interest, and they needed to apply existing knowledge to the online cases. The authors concluded that these perceptions were indicative of learning processes that form a deep approach.

Finally, a recent study by Creevy et al. (2017) explored how expert commentary and student reflection in a CBEL platform used in an advanced gastrointestinal tract disease course impacts decision making skills. First- and second-year students interacted with online cases that had a number of pre-determined decision points. After each decision point, students were
allowed to reflect on their decisions and the thought processes of experts making similar decisions, and revise their original decision should they feel it was appropriate. First-year students were randomly assigned to either an online case group or traditional lecture group, and performance on the course final exam was compared. The authors suggested that because there was no significant difference in performance between both groups, the e-learning modules were as effective as traditional lectures for content delivery. Improvement in scores between original and revised answers was observed in four of five decision points in second-year students. The authors concluded that the ability to rehearse clinical decision making through this tool, without direct feedback from an instructor, may facilitate students' problem solving from a structured classroom space to an unstructured clinical environment.

1.4 Outcome-Based Education

Outcome-based education is an approach in education where decisions about the curriculum are driven by outcomes that students should be able to display at the end of a course or program (Davis, 2003). These outcomes are decided prior to course development, and the curriculum is then guided by these outcomes (Davis, 2003). All decisions about content and how it is organized, educational strategies, teaching methods, assessment procedures and the educational environment are made in the context of the learning outcomes that have been predetermined. Outcome-based education has been described as “results-oriented thinking”, where the end goal and purpose of a course dictates what is taught and assessed (Davis, 2003). The opposite has been referred to as “input-based education”, where emphasis is placed on the development of the educational process in a course and the impending results are accepted as they occur (Davis, 2003).
Many advantages of outcome-based education have been cited. Outcome-based education creates the ability to address new and upcoming issues or topics in medicine, making the curriculum relevant in the context of current employment trends (Harden, 1999). In addition, the curriculum may become more clear and well-defined should outcomes be explicitly created and communicated (Harden, 1999). Finally, student-directed learning is encouraged and promotes accountability as a clear framework of goals and expectations of the course are provided (Harden, 1999). Overall, outcome-based education creates a learning environment where the skills and competencies a student is expected to demonstrate as a professional are prioritized and dictate how the curriculum is designed.

Outcome-based education has emerged as a priority in healthcare education. As a result, the CanMEDS Physician Competency Framework was created in human medicine (Frank & Danoff, 2007). This initiative is outcome-oriented and outlines the abilities needed by all physicians to meet the healthcare needs of the patients and communities they serve in their profession (Frank & Danoff, 2007). This framework is being used to set the standards in human medical education and curriculum as well as faculty development (Frank & Danoff, 2007). The CanMEDS Physician Competency Framework has been shared and implemented worldwide in an effort to support and improve physician development. Many other professions, including veterinary medicine, have adopted CanMEDS to aid in the development of their own curriculums (Frank & Danoff, 2007).
Thesis Overview and Objectives

The primary goal of this study was to gain an insight into veterinary students’ perceptions of the use and effectiveness of a purpose-built CBEL tool in a second-year course at the OVC. Specifically, we aimed to evaluate changes in veterinary students’ perceived knowledge and skills, learning behaviour, as well as satisfaction and attitudes when using a CBEL tool. This goal was addressed by conducting exploratory focus groups as well as pre- and post-use questionnaires to gain a better understanding of students’ perceptions of CBEL and to evaluating its perceived effectiveness. Due to its use in other healthcare education programs, we aimed to provide evidence and further validate CBEL as a useful and accepted method of teaching and learning in veterinary medical education.

The specific objectives of this study are as follows:

1. To investigate students’ views around the utility and usability of a CBEL tool, including recommendations for future design, implementation and use (Chapter 2);
2. To assess students’ perceptions of satisfaction and enjoyment prior to and after the use of a CBEL tool (Chapter 2);
3. To evaluate students’ perceived effectiveness of a CBEL tool (Chapter 3);
4. To measure students’ self-confidence in application and use of clinical knowledge and skills when using a CBEL tool (Chapter 3);
5. To explore the relationship between perceived learning preferences of veterinary students and the use of CBEL (Chapter 3);
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CHAPTER TWO

Investigating the learning experiences of second-year veterinary students using a case-based e-learning tool in a clinical medicine course at the Ontario Veterinary College

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Abstract

Exposure to real-life clinical cases has been regarded as the optimal method of achieving deep learning in medical education. Case-based e-learning (CBEL) has been considered a promising alternative to address challenges in the availability of teaching cases and standardizing case exposure. While the use of CBEL has been positive in veterinary medical education, insight into how to best deliver CBEL, including evidence as to whether students value its use in their education are important considerations. This study investigated students’ views around the utility and usability of a CBEL tool and assessed students’ perceptions of satisfaction and enjoyment with the tool. Through the use of focus groups as well as pre- and post-use questionnaires, students expressed that the design and utility of the online cases, including their authenticity, played an instrumental role in perspectives and acceptance of the CBEL tool. Students explained that authenticity created a more realistic learning experience, that may in turn translate to increased confidence and better preparedness in real life practice. Logistical considerations such as the inclusion of costs, and the visual aspects of case design were also considered important, indicating that logistic factors may be equally as important as visual aspects of case design. Findings of this study can help guide educators in the future design and implementation of online cases in various capacities, allowing practical implementation of CBEL in veterinary medical education.

Key words: case-based e-learning, e-learning, case-based learning, blended learning, virtual patients, electronic cases, clinical reasoning, learning styles, learning behaviour
Introduction

Recent years have seen undergraduate and postgraduate education subject to pressures to provide students with qualities such as critical thinking, problem solving, and the tools to carry out lifelong learning (Allenspach et al., 2008). In healthcare education particularly, challenges include providing realistic or hands-on learning opportunities for students to apply theoretical knowledge in a clinical setting. In veterinary medical education, as with human medical education, deep learning is desirable as it prioritizes understanding over memorization by relating ideas through evidence-based practice and extracting meaning behind related concepts (Allenspach et al., 2008; Monahan & Yew, 2002.; Newble & Entwistle, 1986). Deep learning may also help in the process of facilitating a link between theoretical knowledge and clinical application, helping with the understanding of complex, interrelated concepts that are typically present within clinical cases (Allenspach et al., 2008; Monahan & Yew, 2002; Newble & Entwistle, 1986).

In order to promote deep learning, student-centered, inquiry-based learning methods like case-based learning (CBL) have been widely adopted into veterinary curricula (Eurell et al., 1999; Fajt et al., 2009; Krockenberger et al., 2007; Patterson, 2006; Pickrell et al., 2002; Sharkey et al., 2012, 2007). Typically, in CBL, real or realistic case material is presented to students where they are typically required to address and ultimately solve the case at hand. In recent years, limitations of space and physical resources, and the variability in consistent availability of real-life teaching cases has meant that alternative ways to replicate the CBL experience have been sought. Case-based e-learning (CBEL) has been recognized as a promising alternative (Rowe et al., 2012; Ruiz, et al., 2006). CBEL involves an electronic or online
delivery of CBL. Recognized advantages of CBEL include: standardization of course content and delivery (Ellaway & Masters, 2008); a bridge between lecture knowledge and clinical application; simulation of in-the-moment decision-making processes with presentation of immediate consequences or outcomes of decisions made (Ellaway & Masters, 2008); maintaining an interactive learning component (Ellaway & Masters, 2008); allowing for cases to be revisited on demand, giving students the opportunity to practice approaching a clinical case at their convenience (Ellaway & Masters, 2008); reduced delivery cycle time (Welsh et al., 2003); and lower expenses of delivery once established (Howlett et al., 2009). Also recognized are a number of elements identified as critical to the success of CBEL, including: effective design and utility; the influence of instructor or supervisor teaching approach when delivering CBEL; students’ acceptance and enjoyment (Govindasamy, 2001); technological support (Welsh et al., 2003); effective incorporation of pedagogical principles; and the question of how to sustain learner motivation in using the learning tool (Welsh et al., 2003).

In human medical education, CBEL has been extensively explored and utilized, and frequently implemented in medical programs around the world. Overall, CBEL typically garners positive results, especially when used in a blended learning environment with traditional didactic lectures (Kolb et al., 2009; Taradi et al., 2005). Students report satisfaction and enjoyment towards CBEL as well as increased knowledge in subject-matter in courses utilizing this learning modality (Gaupp et al., 2016; Howlett et al., 2009; Kandasamy & Fung, 2009; Kolb et al., 2009; Taradi et al., 2005). In addition, CBEL has been shown to be more effective and more efficient at achieving pre-determined learning outcomes when compared to traditional teaching methods (Kandasamy & Fung, 2009).
In veterinary medical education, to date, CBEL has been utilized in limited capacity. Trace et al. (2012) explored the effect of student development of teaching cases to enhance the quality of the clinical learning experience and assist in the development of clinical reasoning skills. The authors reported that creating and using cases were useful for the students and that the experience improved their approach to a clinical case. Kleinsorgen et al. (2018) evaluated the impact of optional online cases on learning progress and success in a veterinary biochemistry course. The authors demonstrated a weak correlation between performance in the online cases and performance in final exams, however, concluding that the online cases increased student motivation in the subject of veterinary biochemistry. Finally, Creevy et al. (2017) studied the use of expert commentary and student reflection using a CBEL platform, reporting that the e-learning module was as effective as traditional lecture for content delivery. They also concluded the use of expert commentary and student reflection in a CBEL tool may facilitate students’ transition from problem solving in a well-structured classroom setting to an ill-structured clinical setting.

To our knowledge, there are currently no studies evaluating the learning experience of veterinary students when using a CBEL tool. Exploring these needs may provide insight into the effective design, utility and delivery of a CBEL tool in veterinary medical education. Subsequently, evaluating student satisfaction and enjoyment of this tool may provide evidence as to whether students value its use in their education, creating a potential platform for effective implementation and use in veterinary medical education. Evaluating satisfaction and enjoyment in learning is important because perceived usefulness and perceived satisfaction both contribute to learners’ behavioural intention to use an e-learning system (Liaw, 2008).
Case based e-learning was implemented in a second-year clinical medicine course at the Ontario Veterinary College (OVC). Online cases depicting common clinical problems were developed using Articulate Storyline 2®, an e-learning development tool. Online cases were implemented to help students apply clinical knowledge to realistic case-based scenarios, and to assist in teaching a methodical approach to a clinical case.

The aims of this study were to investigate students’ views around the utility and usability of a CBEL tool, including recommendations for future design, implementation and use; and to assess students’ perceptions of satisfaction and enjoyment prior to and after the use of a CBEL tool.

Methods

Study Design and Participants

An exploratory mixed-methods design was used. Focus groups discussions were conducted that subsequently informed the design of pre- and post- case-based e-learning use questionnaires delivered to second-year Doctor of Veterinary Medicine (DVM) students. Participation in the study was voluntary and there was no impact on course grades. Students received a gift card honorarium and a meal for participating in the focus groups or inclusion into gift card draws for completing each questionnaire.

All students gave written informed consent to participate in the study. The study was approved by the Research and Ethics Board at the University of Guelph (REB#17-01-009).
Research Setting

A second-year clinical medicine DVM course at the Ontario Veterinary College (OVC), University of Guelph, Canada served as the primary research setting for this study. The lecture- and lab-based course is designed as a blended learning environment and requires students to learn about common presenting problems and the associated pathophysiological disease processes. The lab component of the course provides students the opportunity to apply knowledge learned in lectures through the use of online case-based material presented in the form of e-learning. Each lab session focuses on a different presenting problem as taught in lectures. Five different small animal cases were available for each presenting problem discussed in lectures. For example, five cases are made available for the presenting problem of vomiting and were housed on the University of Guelph’s learning management system, CourseLink. Four groups, each consisting of 31 students attend a lab time per group and are given the opportunity to work collaboratively or individually on the online cases available to them. Students are required to pick one case to investigate further and submit a medical record assignment based on that case. Completion of all cases is not mandatory but is encouraged. Teaching faculty are present in lab sessions to answer any questions that arise in relation to the cases or lecture material. All cases were made available to students for the duration of the course.

e-Learning Platform Articulate Storyline 2®

The e-learning tool Articulate Storyline 2® is an online platform specifically designed for creating, distributing and evaluating interactive courses, and was used for all cases in this project. Each case presents a realistic scenario involving a patient presenting for a medical
complaint, and navigates the student through history taking, doing a physical exam, creating problem lists, selecting investigatory tests and procedures, developing a treatment plan and follow up considerations. Cases were optimized to present information as realistically as possible and to minimize logistic technical complications, ensuring that the focus is on learning the process of navigating a clinical case and applying lecture knowledge. Cases were designed based on the principles of outcome-based education where the desired learning outcome for each case was decided upon first, and then the case was specifically constructed to meet the set learning outcome. Each case took approximately eight to ten hours to design, build and implement for the course. Cases were designed with radio buttons, check boxes or click and drag options implemented at each clinical step to simulate a decision-making process. If incorrect options are selected, feedback is typically provided in the cases in the form of a pop-up message box, with explanations provided as to why this may be the case. Various clinical steps (e.g. differential diagnosis) include text boxes, either embedded or that appear when hovering over an option. Text boxes provide important clinical knowledge that explain in more detail the rationale required in the particular clinical step or the pathophysiologic manifestations of the presenting problem. A screenshot of a page from one of the cases showing selection options is seen in Figure 1.

Data Collection

Focus Group and Interview Structure

Focus groups and a single one-on-one interview were conducted with the graduating class of 2019 between March and May 2017, at the OVC. This class was chosen for focus groups as
they were given the opportunity to use the CBEL tool in the clinical medicine course throughout the 2016/2017 academic year and were interviewed shortly after completing their use of the CBEL tool in the course. An interview guide was used in all discussions that consisted of four main topics: usability, students’ satisfaction, perceived effectiveness in students’ learning, and overall assessment of the case-based e-learning tool including recommendations for its use in veterinary education. Discussions were audio recorded, transcribed verbatim, and de-identified.

Pre- and Post-use Questionnaires

Two matched questionnaires were designed using results from the focus group discussions and included participant demographics as well as specific topics of learning behaviour and CBEL considerations such as: perceptions of utility and usability of the tool in the course; the inclusion of various case design elements; the social environment and supervisor availability while using the CBEL tool; and satisfaction and enjoyment with the use of the CBEL tool in the course. Both questionnaires were delivered online from October 2017 to March 2018 to the graduating class of 2020 through the Qualtrics® survey tool. This class was given the opportunity to use the CBEL tool in the clinical medicine course throughout the 2017/2018 academic year. There were no curricular changes between the 2016/2017 and 2017/2018 academic years.

The pre-CBEL use questionnaire was delivered in the first lab session of the course to determine students’ preliminary perceptions about case-based e-learning prior to its use. An introductory presentation about the labs as well as the use, purpose and rationale behind case-based e-learning was also provided in the first session. Students were given time to access and
complete the questionnaire in the first lab. The post-use questionnaire was delivered one week after completion of the course.

Data Analysis

Qualitative Data

Transcripts were analyzed using thematic analysis (Braun & Clarke, 2006). This involves repeated listening of audio recordings and reading of verbatim transcripts to allow for familiarization of data, examining transcripts line-by-line, and assigning codes. Codes were checked and reviewed, and similar concepts were grouped into categories to identify initial themes and subthemes. Themes were then revisited, refined, defined for clarity and accuracy, and explored in order to determine any interrelated relationships and connections.

Quantitative Data

All pre- and post- questionnaire data analysis was conducted using SAS 9.4 (SAS Institute Inc., Cary, NC, USA). Pre- and post-use scores between students were compared using the nonparametric Wilcoxon signed-rank tests for all questions containing Likert or ranked data due to the assumption that all data was non-normally distributed. Significance level was set at \( p \leq 0.05 \). Demographics were analyzed using descriptive statistics.
Results

Questionnaire Quantitative Data

Response Rate and Demographics

One hundred and eighteen second-year veterinary students out of one hundred and twenty-four enrolled in their cohort (95%) completed the pre-use questionnaire. One hundred and nine students completed the post-use questionnaire (87.9%), of which, one hundred and six completed both questionnaires (85.5%). The study cohort is comprised of these 106 students. 98% of respondents were female, which was representative of the 94% female distribution of the graduating class of 2020 at the OVC. Mean age of respondents after the pre-questionnaire was 24.1 years with majority of students hoping to enter mixed animal (48%) or small animal (41%) practice in the future.

CBEL Utility and Design Considerations

Significant increases in mean score were observed in the post-questionnaire in all but one aspect of CBEL utility. Students reported a decrease in mean score from 2.46/5 to 2.20/5 after the post-questionnaire when asked if the technical aspects of using a CBEL tool would limit or hinder learning, although this was non-significant (p = 0.093). The greatest increase was seen in the item asking if the CBEL tool was well designed and easy to use, with 91.51% of students either agreeing or strongly agreeing with this statement (Table 2.1).

Students reported a mean score of 7.06/10 or greater in all design elements, other than the use of sound (6.39/10), post-CBEL-use (Table 2.2). Most notably, the importance of displaying a
complete case scored highly prior to CBEL-use (M = 8.90) and significantly increased post-use (M = 9.23, p = 0.039). Cost considerations was also rated highly pre- (M = 8.20) and post-use (M = 8.17).

Learning Environment in CBEL Delivery

Prior to using the CBEL tool, students indicated moderate agreement that working with peers would allow for a positive social environment (M = 3.64), which significantly increased after using the CBEL tool (M = 3.86, p = 0.033.) Students also disagreed that they preferred to work by themselves due to the potential for negative social repercussions from knowing less than their peers (M = 2.61), which did not significantly change after using the CBEL tool (M = 2.63, p = 0.836) (Table 2.3).

Similarly, students moderately believed that a supervisor must be actively involved while working through the online cases prior to using the CBEL tool (M = 3.31), which significantly decreased post-use (M = 2.85, p<0.001). Although a significant change was not seen post-use, students strongly agreed that a supervising professor should be available to answer questions related to the online cases but does not need to be actively involved in working through the cases (M = 4.05) (Table 2.3).

Satisfaction and Enjoyment with CBEL

Overall, students ranked all satisfaction scale items highly post-use, with all positive items scoring greater than 3.92/5 (Table 2.4). After using the online cases, students reported that CBEL could not replace real case experience (M = 2.91). Prior to CBEL-use, students indicated
that CBEL is a good bridge between traditional lecture-based teaching and learning from a real case (M = 4.04), significantly increasing post-use (M = 4.47, p<0.001).

Students’ perceived enjoyment in using a CBEL tool improved significantly in all pre- and post-use questionnaire statements (Table 2.4). All post-use mean scores were 4.26/5 or greater. The greatest difference in pre- and post-use score was in confidence in using a CBEL in learning, with an increase of 0.71 in mean score (p<0.001).

Focus Group Qualitative Data

Two major themes resulted from thematic analysis of focus group transcripts: (1) User Engagement, and (2) Relation to Real Life. These themes are particularly relevant because they directly describe students’ perceptions of the utility of the CBEL tool and contribute towards recommendations for future CBEL design and use based on satisfaction and reactions after its use in the clinical medicine course.

Theme 1: User Engagement

Several students commented that the CBEL tool was accessible in nature which contributed to an increased level of engagement while working through the online cases. One student mentioned that they “thought it was good that we could access [these cases] on CourseLink (P11)” and that their friends “…did it at home and it worked (P11).” Another participant expanded on the benefits of being able to access the online cases outside of the classroom, stressing that the ability to work on your own time was beneficial for their learning experience:
P09: “I like [that] I can go home at the end of the day and I can sit and do them at my computer at home to know if I’m actually learning things. We had some… where you can sit and you can watch the videos and you can click on things, things we didn’t have time in class to do.”

After discussing the accessibility of the online cases, students moved on to explaining how the design and utility of the CBEL tool affected their user experience. Mixed perceptions were reported, with many ideas centred around technical aspects of the online cases. One student explained the benefit of having multiple attempts at selecting a correct answer as well as the ability to learn from additional feedback provided:

P04: “I liked that if you clicked the wrong answer…it said this is a good thought but rule [this] out because of x, y, z. I liked how if I finished the case and I…wanted to go back and figure out why it wasn’t this or that, you could go back and forth as much as you want.”

Although this was seen as a design benefit, one student expressed frustration with the length it could take to find the correct answer based on how the case progression was designed:

P03: “You’d have a problem list and you’d have to check off which ones are right…[It} was nice that it wouldn’t just tell you the answer but then [I’d think] one of these is right, is not right, or I’m missing one and I’d have to click through different combinations [to move on] and I remember that being a bit of a pain.”
Aside from any technical feedback, one student commented on the overall design of the online cases, explaining that they were well organized and beneficial because the clinical approach was modelled on how a veterinarian would approach a case:

P02: “I think it was nice the way it was organized, [specifically] working through a case as a vet would, from initial presenting complaint to what you would work up like bloodwork or anything like that. It was supported by the ease of pressing a button and [navigating] through [the cases], [so] it was pretty easy to use.”

Overall, students tended to express that the cases were well-designed, however, technical aspects of the tool could hinder their learning experience.

Although there were mixed perceptions of the technical aspects of the online cases, the most highly cited benefit was the interactivity of the CBEL tool. Students compared the online cases to other learning experiences they have had, indicating that the online cases were superior and added more depth to their learning. One student explained that “compared to other online [learning tools] … this was more interactive which was better because it’s more engaging. It gets you thinking a lot more whereas [with] videos, you’re just sitting there watching (P11).”

Particularly, one student described that the interactivity of the online cases created an environment where they felt like they were practicing as opposed to memorizing, which was important in being able to recall the knowledge and skills learned from the online cases later on:

P02: “I think the advantage of these is that you’re the one that’s working through the case. You’re not relying on some professor’s notes that you’re memorizing.”
That’s not a form of learning that’s conducive to being able to practice those skills later on. You’re the one that’s making the decisions with these modules, you’re the one selecting what you would do, so I think that’s a more effective way for many of us to actually learn the material…I think that’s a huge advantage of these. As opposed to just reading and reading and reading, it’s interactive. …it feels like you’re actually doing the exam without actually physically hands-on doing it sometimes or making a diagnosis without an animal in front of you necessarily, but it simulates that pretty well.”

Theme 2: Relation to Real Life

Closely related to the subtheme of design and usability, many students commented on the accuracy and realism of the online cases. Students discussed their needs pertaining to realism and explained that this affects their ability to apply their online case experience to real life situations. Specifically, students voiced that cost considerations were an important factor to include when designing the online cases. One student explained that the absence of cost led to an unrealistic experience and that its inclusion would add an extra layer of treatment consideration that is more realistic post-graduation:

P11: “I feel like my biggest issue with [the online cases] has always been the diagnostic tests because it always…gives every single test as an option for you and I felt like in real life that’s usually not possible. Usually you need to pick one that you’re going to do first, then followed by another one if you need it. Cost-
wise, that’s the way it’s going to work too…and I feel like if it was incorporated it would help us learn.”

Students continued to express that the cases could be expanded to include more detail. One student explained that by doing so, this creates the opportunity to be fully exposed to a wide range of realistic cases which may be difficult to achieve in a clinical setting:

P07: “I think it’s just an opportunity to also expose us to things that we’re not going to see…so that you have a general idea of how things are done. Because in clinic, people don’t always have the time to explain that to you. So, I think even if those cases went in to more depth…people may find it more beneficial because you don’t see it, and it’s a chance to see it the way they want you to.”

Overall, students were in consensus that the cases acted as a good bridge between lecture and real-life practice, but that the latter was still superior and that it should not be replaced with online cases. One student explained that it is a great idea to be able to come in to a real case more confident because of exposure through online cases, however, the real-life practicality is still important to consider:

P01: “Yes it’s a nice bridge but…[real life practice] is still necessary even with these modules. There’s definitely a lot of aspects you can take away from doing these modules, but practicing some things like restraint or surgery [on a live animal], we’re going to have to do these in the future. …I think going in to it confident is really important, but making sure we do have access to live animal is also very important.”
Similarly, students discussed the number of cases available to them in the course. Generally, students explained that more cases along with a variety of cases would be beneficial. One student explained that after working through the available cases once, they were not as beneficial because the answers had been memorized:

P09: “If it’s a learning aid to reinforce the concepts in lecture, that’s great to have in the lab. If it’s a study aid, I need to have a bank of 25 of them online so that I can sit at home…and go through things that I’ve never seen before. It’s no benefit for me to redo the ones that we did in lab because I remember the answers and I don’t get that problem solving [or] get to work through the case.”

Finally, students discussed the practicality of the online cases and how they related to live animal experience, particularly valuing the time efficiency of the online cases because they provide a similar practical aspect with less preparation:

P05: “I really liked it because compared to doing labs in person, [the in-person labs] take a lot longer to physically change everything. But doing it online, you get the same experience of having the practical aspect of what you’re trying to learn…Doing a physical exam takes twenty minutes to do but you can just hover over all the key aspects of the animal to learn the same information. So you get the same experiences but in a more efficient manner, especially with one hundred and twenty of us. Doing a physical exam on a dog isn’t practical so I think the program itself does a good job of replacing that time-consuming thing.”
Discussion

Overall, students were highly satisfied with the CBEL tool and enjoyed using it in the clinical medicine course. The social environment and social dynamics of CBEL use in the course were also positively described. Although students believed that the online cases were well-designed and easy to use, several caveats were reported regarding technical aspects and utility of the cases where students provided insight into improvements for future design and use of online cases.

When asked about the social environment associated with using a CBEL tool, students reported positive experiences working with their peers. Specifically, they indicated that the CBEL tool created a positive learning environment where they felt comfortable working with their peers without any social repercussions. This is consistent with previous research which found that although veterinary students tend to be achievement-motivated, individual learners, they can be persuaded of the benefits of collaborative learning, especially in a case-based learning scenario (Khosa et al., 2010). Results from our study also compliment research by Ellaway & Masters (2008) who reported the idea that the integration of technology and online learning into traditional curricula supports and encourages the capacity to communicate and collaborate with peers. This is important to note as a negative social environment may discourage students from using a CBEL tool, thereby negating any potential for effectively achieving pre-determined learning outcomes. More importantly, there is a clear necessity for improved communication skills and the ability to work well in teams when in a clinical setting. This is especially the case in post-education in clinical practice where the success of collaboration often improves clinical outcomes and patient experience (Schmitt, 2001). E-
learning cases such as the ones used in this study provide a platform to practice these skills and experience a collaborative clinical setting in a safe space prior to practice with live animals. Further research into the social dynamics of the use of a CBEL tool may be necessary to determine an optimal method of implementation in veterinary medical education.

One of the key components of CBL is the ability for students to consult an instructor for feedback and guidance in an effort to achieve learning objectives (Srinivasan et al., 2007). Having an instructor present while using CBEL allows for constructive feedback, as well as necessary assistance to provide technical support in instances where a CBEL tool does not function properly. Students in our study reported that a supervising instructor does not have to be actively involved during CBEL use. However, the supervisor should still be present and available to answer questions as well as guide discussion. Seabra et al. (2004) reported in human medical education that an instructor was essential to students’ learning experience with an e-learning tool and that the tool could not fully replace the instructor. Short and McConnell (1997) similarly explained that technology could be used not to replace an instructor, but as an aid in order to allow instructors to be more efficient in their use of time. In addition to instructor feedback, students valued the inclusion of feedback within the CBEL tool itself at each step of the clinical cases. This feedback allowed them to reflect on successes and mistakes, learning the reasoning behind each decision in a case and how to efficiently and effectively apply the knowledge they have learned in class. In human medical education, feedback has been demonstrated to be imperative in developing clinical reasoning skills (Huwendiek et al., 2009). Creevy et al. (2017) reported that expert feedback within a CBEL tool similarly improved clinical decision making in veterinary students. Our findings suggest that a blended type learning
environment, involving an e-learning tool and the presence of an instructor, may be the optimal method of delivering CBEL.

The overall positive perceptions of satisfaction and enjoyment are important in the successful implementation of the CBEL tool. As Liaw (2008) explains that in an e-learning capacity, perceived usefulness and perceived satisfaction both contribute to learners’ behavioural intention to use an e-learning system. Students in our study reported a high level of satisfaction and enjoyment with the CBEL tool. It was noted by participants that they enjoyed the interactivity of the tool, explaining that it created the opportunity to practice and apply knowledge and skills learned in lecture. The opportunity to practice may result in increased confidence in a clinical setting when applying knowledge and skills learned using CBEL. Patterson (2006) previously demonstrated that increased confidence resulted in improved clinical reasoning skills after CBL. Interestingly, Winder et al. (2017) showed that online resources may not necessarily be as beneficial with regards to technical skill training, however, the authors did state that they may be beneficial when used in addition to hands-on practice. Furthermore, students in our study expressed that the interactivity of these online cases made them superior to other online resources and cases they had previously experienced which increased their level of engagement when using the CBEL tool. This too helped students feel like they were practicing over memorizing, which helped with recall of concepts that the online cases targeted. Other factors that were reported by our students to contribute towards increased engagement included accessibility and practicality of the cases, which have been previously cited as advantages of e-learning applications (Welsh et al., 2003). The accessibility and practicality of the cases was beneficial for students’ learning experiences because the ability to work at their own pace and at
their own convenience allowed students to be more immersed in the use of the cases with increased efficiency. Similarly, Patterson et al. (2007) reported that students who enjoy the manner in which material is being taught tend to better achieve learning outcomes. The positive perceptions of satisfaction and enjoyment that the students in this study reported towards the CBEL tool provides a platform for the online cases to be an effective teaching modality in the course.

Although students generally reported positive feedback regarding the online cases, a number of caveats were noted. Students indicated that they had to feel engaged through solid technical design and utility. Technical factors can easily discourage students from using or enjoying CBEL, thereby creating a situation where students do not support the use of a CBEL tool. As a result, the effectiveness of the tool may be jeopardized and learning opportunities may be missed. Welsh et al. (2003) supports this notion, explaining that as long as technical difficulties are not overwhelming, participants who use technologically-driven learning methods have positive attitudes, are satisfied with their learning experience, and are willing to use it again. Shee and Wang (2008) similarly report that students highly value the user interface of web-based e-learning applications, even over the content included in them. Future design of online cases should focus on improved utility to create a situation where learning is not overshadowed by technical difficulties.

In the future, we would also consider making the online cases more realistic. This has been cited as important for the learning behaviour of students (Huwendiek et al., 2009; Jin & Bridges, 2014). In human medicine, a number of design features have been noted to be important in the successful creation and implementation of virtual patients and online cases. Jin and
Bridges (2014) reported in a systematic review that providing rich, authentic problems and case contents in electronic problem-based learning applications was associated with positive learning outcomes in medical students. Similarly, Huwendiek et al. (2009) recommends ‘adequate use of media’ to create clinical cases that are as realistic as possible, including pictures or video of the patient and specific clinical findings in the case. In simulation-based teaching modalities, higher fidelity simulations are preferred by students because they provide more context to understanding complex principles and tasks and have been shown to better promote a transfer of clinical abilities to real patients (Issenberg et al., 2005). Participants in our study reported that online cases must be designed as realistically as possible in order to be beneficial for their learning. They explained that by doing so, a more representative and memorable experience is created which they felt might make them more prepared for live animal practice. This being said, the greater the authenticity, complexity, and fidelity of the cases, higher the likelihood of experiencing challenges with technical and time considerations in case production and scalability. Practicality may ultimately dictate the balance between available resources and designing cases with increased authenticity and feasibility. This is especially true when considering the ultimate goal of providing sufficient case exposure to achieve the learning goals of the course and the DVM program. This is typically not a concern with CBL, as traditionally, real case material is often used. The addition of real videos or pictures as well as sound, if appropriate may help create the more authentic experience that students desire.

A little unexpectedly for the researchers, students expressed the desire for cost considerations to be included in the design of cases in the focus groups which was further validated in both questionnaires. Prior to using the CBEL tool in the course, students were told
that the purpose of the online cases was to help apply lecture knowledge to clinical case examples as well as to help learn a methodical approach to a clinical case. Factors such as cost considerations were not originally considered important when designing the online cases because there was concern that this may add an extra layer of complexity to the cases that could potentially take away from the original purpose of knowledge application and learning a methodical approach to a clinical case. Although the decision to include or exclude costs in clinical cases should be made based on the learning objectives of the case and in the course, this may provide insight into the level of detail and exactness that students are looking for when using a CBEL tool, demonstrating that logistic considerations may be equally as important as visual aspects of case design.

The use of CBEL in any course may have several challenges, including the considerable time and effort required to design each online case. Each of our cases took approximately eight to ten hours to complete from start to finish, including a considerable learning curve to learn how to use and operate Articulate Storyline 2®. Regardless of the e-learning software chosen to construct online cases, learning how to use the required software may present as a daunting task, and can be highly dependent on an individual’s technical skills and proficiencies. Furthermore, the implementation of CBEL typically has higher setup costs, although this tends to decrease once implemented (Howlett et al., 2009). Although these challenges may exist, the use of software like Articulate Storyline 2® may help to reduce faculty and staff development time and institutional costs, increasing the feasibility of technologies such as this. Findings of this study can help guide future educators in the design and implementation of online cases in other
capacities to hopefully improve on some of the challenges, allowing practical implementation of CBEL in veterinary medical education.

Limitations

This study measured self-reported attitudes towards CBEL use in a clinical medicine course with students who are still early in their veterinary medicine program. Attitude and reactions may be varied in cohorts who are further along in their program. Additionally, there was no comparison group to determine if the results reported differ with other learning modalities such as CBEL-use outside of a blended learning environment, traditional didactic lectures, or traditional CBL. The within-subject design with pre- and post-use evaluation only detects short term effects. Repeated measures and a longer follow-up timeframe may be necessary to evaluate long-term attitudes. Generalizability may be limited as participants were only recruited from one academic institution. There is a possibility of bias as a result of students having positive perceptions of the clinical medicine course or from student excitement in using a new learning modality in the course. This may result in inflated positive results, particularly in the pre-use questionnaire. Finally, the voluntary nature of the research may lead to selection bias, as those who were more motivated in the course may have chosen to participate. However, the high response rate in the study may negate this.

Conclusion

Our results support the notion that CBEL is a viable option as a learning modality in veterinary medical education. Students demonstrated high satisfaction and enjoyment with a CBEL tool used in a clinical medicine course, indicating an acceptance of its use in teaching how
to apply lecture knowledge to clinical cases, as well as how to methodically approach a clinical case. Students reported positive perceptions of the accessibility, interactivity, and practicality of the online cases, explaining that they helped improve their learning experience in the course. The design and utility of the online cases as well as their authenticity played an instrumental role in students’ perspectives and acceptance of the CBEL tool. Students expressed that more authentic cases create a more realistic learning experience that may translate to increased confidence and better preparedness in real life practice. Utility perspectives and student acceptance of CBEL should be considered in future design and implementation of a CBEL tool. The results of this study provide a platform for further exploration of this learning modality in veterinary medical education as well as future considerations when implementing CBEL in other capacities.

Notes

i. Articulate Storyline 2, Articulate Global, Inc., New York, NY, USA

ii. CourseLink, University of Guelph, Guelph, ON, Canada

iii. Qualtrics Survey Software, Qualtrics LLC, Provo, UT, USA

iv. SAS 9.4, SAS Institute Inc., Cary, NC, USA
REFERENCES


LIST OF TABLES

Table 2.1: Students’ responses to questions regarding the utility of a case-based e-learning (CBEL) tool in a second-year clinical medicine course. Frequency distribution, mean score, and significance of students’ perceptions are reported, pre- and post-CBEL use, using the nonparametric Wilcoxon signed-rank test.

Table 2.2: Students’ responses to questions regarding the importance of various design elements of a case-based e-learning (CBEL) tool used in a second-year clinical medicine course. Frequency distribution, mean score, and significance of students’ perceptions are reported, pre- and post-CBEL use, using the nonparametric Wilcoxon signed-rank test.

Table 2.3: Students’ responses to questions regarding social environment and supervisor availability while using a case-based e-learning (CBEL) tool in a second-year clinical medicine course. Frequency distribution, mean score, and significance of students’ perceptions are reported, pre- and post-CBEL use, using the nonparametric Wilcoxon signed-rank test.

Table 2.4: Students’ responses to questions regarding their perceived satisfaction and enjoyment of a case-based e-learning (CBEL) tool in a second-year clinical medicine course. Frequency distribution, mean score, and significance of students’ perceptions are reported, pre- and post-CBEL use, using the nonparametric Wilcoxon signed-rank test.
Table 2.1: Students’ responses to questions regarding the utility of a case-based e-learning (CBEL) tool in a second-year clinical medicine course. Frequency distribution, mean score, and significance of students’ perceptions are reported, pre- and post-CBEL use, using the nonparametric Wilcoxon signed-rank test.

<table>
<thead>
<tr>
<th>CBEL Utility</th>
<th>N</th>
<th>SD (%)</th>
<th>D (%)</th>
<th>N (%)</th>
<th>A (%)</th>
<th>SA (%)</th>
<th>Mean</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I feel comfortable using an e-learning tool for my learning</td>
<td>Pre</td>
<td>106</td>
<td>0.94</td>
<td>5.66</td>
<td>24.53</td>
<td>46.23</td>
<td>22.64</td>
<td>3.84</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>106</td>
<td>0.94</td>
<td>0.00</td>
<td>1.89</td>
<td>46.23</td>
<td>50.94</td>
<td>4.46</td>
</tr>
<tr>
<td>2. The case-based e-learning tool is well designed and easy to use</td>
<td>Pre</td>
<td>106</td>
<td>2.83</td>
<td>4.72</td>
<td>36.79</td>
<td>43.40</td>
<td>12.26</td>
<td>3.58</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>106</td>
<td>0.00</td>
<td>2.83</td>
<td>5.66</td>
<td>38.66</td>
<td>52.83</td>
<td>4.42</td>
</tr>
<tr>
<td>3. An online method of delivery of the cases is beneficial for my learning</td>
<td>Pre</td>
<td>106</td>
<td>1.89</td>
<td>4.72</td>
<td>28.30</td>
<td>50.00</td>
<td>15.09</td>
<td>3.72</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>106</td>
<td>0.00</td>
<td>0.94</td>
<td>7.56</td>
<td>47.17</td>
<td>44.34</td>
<td>4.35</td>
</tr>
<tr>
<td>4. The technical aspects of using a case-based e-learning tool limit or hinder my learning</td>
<td>Pre</td>
<td>106</td>
<td>20.75</td>
<td>33.96</td>
<td>28.30</td>
<td>12.26</td>
<td>4.72</td>
<td>2.46</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>106</td>
<td>49.06</td>
<td>21.70</td>
<td>4.72</td>
<td>9.43</td>
<td>15.09</td>
<td>2.20</td>
</tr>
</tbody>
</table>

Likert-scale item measurements: 1 (SD = Strongly Disagree), 2 (D = Disagree), 3 (N = Neutral), 4 (A = Agree), 5 (SA = Strongly Agree). Mean pre- and post-questionnaire responses of each item were compared using the nonparametric Wilcoxon signed-rank test. Data are expressed as % of the respondents to both questionnaires. *p≤0.05
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<table>
<thead>
<tr>
<th>CBEL Design Elements</th>
<th>N</th>
<th>1 (%)</th>
<th>2 (%)</th>
<th>3 (%)</th>
<th>4 (%)</th>
<th>5 (%)</th>
<th>6 (%)</th>
<th>7 (%)</th>
<th>8 (%)</th>
<th>9 (%)</th>
<th>10 (%)</th>
<th>Mean</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Video of a real animal</td>
<td>Pre</td>
<td>106</td>
<td>5.66</td>
<td>1.89</td>
<td>4.72</td>
<td>7.55</td>
<td>5.66</td>
<td>7.55</td>
<td>13.21</td>
<td>14.15</td>
<td>16.04</td>
<td>23.58</td>
<td>7.13</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>106</td>
<td>6.60</td>
<td>3.77</td>
<td>1.89</td>
<td>2.83</td>
<td>8.49</td>
<td>10.38</td>
<td>8.49</td>
<td>25.47</td>
<td>10.38</td>
<td>21.70</td>
<td>7.09</td>
</tr>
<tr>
<td>Picture of a real animal</td>
<td>Pre</td>
<td>106</td>
<td>6.60</td>
<td>4.72</td>
<td>2.83</td>
<td>5.66</td>
<td>16.04</td>
<td>8.49</td>
<td>11.32</td>
<td>15.09</td>
<td>10.38</td>
<td>18.87</td>
<td>6.60</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>105</td>
<td>5.71</td>
<td>3.81</td>
<td>4.76</td>
<td>4.76</td>
<td>5.71</td>
<td>11.43</td>
<td>8.57</td>
<td>17.14</td>
<td>16.19</td>
<td>21.90</td>
<td>7.06</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>104</td>
<td>10.58</td>
<td>5.77</td>
<td>4.81</td>
<td>5.77</td>
<td>7.69</td>
<td>7.69</td>
<td>14.42</td>
<td>14.42</td>
<td>10.58</td>
<td>18.27</td>
<td>6.39</td>
</tr>
<tr>
<td>Complete case</td>
<td>Pre</td>
<td>106</td>
<td>0</td>
<td>0.94</td>
<td>0</td>
<td>0</td>
<td>1.89</td>
<td>3.77</td>
<td>8.49</td>
<td>16.04</td>
<td>20.75</td>
<td>48.11</td>
<td>8.90</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>106</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2.83</td>
<td>4.72</td>
<td>0.94</td>
<td>11.32</td>
<td>18.87</td>
<td>61.32</td>
<td>9.23</td>
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<tr>
<td>Cost considerations</td>
<td>Pre</td>
<td>106</td>
<td>1.89</td>
<td>1.89</td>
<td>1.89</td>
<td>1.89</td>
<td>2.83</td>
<td>10.38</td>
<td>8.49</td>
<td>13.21</td>
<td>18.87</td>
<td>38.68</td>
<td>8.17</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>106</td>
<td>1.89</td>
<td>1.89</td>
<td>1.89</td>
<td>1.89</td>
<td>2.83</td>
<td>10.38</td>
<td>8.49</td>
<td>13.21</td>
<td>18.87</td>
<td>38.68</td>
<td>8.17</td>
</tr>
</tbody>
</table>

Scale items were measured from 1 (Not at all) to 10 (Extremely). Mean pre- and post-questionnaire responses of each item were compared using the nonparametric Wilcoxon signed-rank test. Data are expressed as % of the respondents to both questionnaires. *p≤0.05.
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<table>
<thead>
<tr>
<th>Social Environment</th>
<th>N</th>
<th>SD (%)</th>
<th>D (%)</th>
<th>N (%)</th>
<th>A (%)</th>
<th>SA (%)</th>
<th>Mean</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Working with my peers allows for a positive social environment</td>
<td>Pre 106</td>
<td>0.94</td>
<td>6.60</td>
<td>34.91</td>
<td>42.45</td>
<td>15.09</td>
<td>3.64</td>
<td>0.033*</td>
</tr>
<tr>
<td></td>
<td>Post 106</td>
<td>2.83</td>
<td>3.77</td>
<td>22.64</td>
<td>46.23</td>
<td>24.53</td>
<td>3.86</td>
<td></td>
</tr>
<tr>
<td>2. I prefer to work by myself because I don’t want negative social repercussions from knowing less than my peers</td>
<td>Pre 106</td>
<td>15.09</td>
<td>35.85</td>
<td>28.30</td>
<td>14.15</td>
<td>6.60</td>
<td>2.61</td>
<td>0.836</td>
</tr>
<tr>
<td></td>
<td>Post 106</td>
<td>23.58</td>
<td>26.42</td>
<td>23.58</td>
<td>16.04</td>
<td>10.38</td>
<td>2.63</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Supervisor Availability</th>
<th>N</th>
<th>SD (%)</th>
<th>D (%)</th>
<th>N (%)</th>
<th>A (%)</th>
<th>SA (%)</th>
<th>Mean</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. A sufficient resource for any technical concerns while using the case-based e-learning tool</td>
<td>Pre 106</td>
<td>1.89</td>
<td>7.55</td>
<td>27.36</td>
<td>50.00</td>
<td>13.21</td>
<td>3.65</td>
<td>0.095</td>
</tr>
<tr>
<td></td>
<td>Post 106</td>
<td>1.89</td>
<td>7.55</td>
<td>27.36</td>
<td>32.02</td>
<td>30.19</td>
<td>3.82</td>
<td></td>
</tr>
<tr>
<td>2. Must be actively involved in working through the online cases with the students</td>
<td>Pre 106</td>
<td>0.94</td>
<td>16.04</td>
<td>45.28</td>
<td>26.42</td>
<td>11.32</td>
<td>3.31</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>Post 105</td>
<td>10.48</td>
<td>38.10</td>
<td>18.10</td>
<td>22.86</td>
<td>10.48</td>
<td>2.85</td>
<td></td>
</tr>
<tr>
<td>3. Should be available to answer questions related to the online cases, but does not need to be actively involved in working through them</td>
<td>Pre 106</td>
<td>0</td>
<td>5.66</td>
<td>13.21</td>
<td>46.23</td>
<td>34.91</td>
<td>4.10</td>
<td>0.737</td>
</tr>
<tr>
<td></td>
<td>Post 106</td>
<td>2.83</td>
<td>8.49</td>
<td>7.55</td>
<td>43.40</td>
<td>37.74</td>
<td>4.05</td>
<td></td>
</tr>
</tbody>
</table>

Likert-scale item measurements: 1 (SD = Strongly Disagree), 2 (D = Disagree), 3 (N = Neutral), 4 (A = Agree), 5 (SA = Strongly Agree). Mean pre- and post-questionnaire responses of each item were compared using the nonparametric Wilcoxon signed-rank test. Data are expressed as % of the respondents.
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### Perceived satisfaction using the CBEL tool

<table>
<thead>
<tr>
<th>Perceived satisfaction</th>
<th>N</th>
<th>SD (%)</th>
<th>D (%)</th>
<th>N (%)</th>
<th>A (%)</th>
<th>SA (%)</th>
<th>Mean</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Helps me in navigating through a clinical case</td>
<td>Pre 106</td>
<td>0</td>
<td>2.83</td>
<td>12.26</td>
<td>66.98</td>
<td>17.92</td>
<td>4.00</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>Post 106</td>
<td>0</td>
<td>0.94</td>
<td>3.77</td>
<td>42.45</td>
<td>52.83</td>
<td>4.47</td>
<td></td>
</tr>
<tr>
<td>2. Allows me to learn more than I would in a traditional lecture</td>
<td>Pre 106</td>
<td>0.94</td>
<td>8.49</td>
<td>20.75</td>
<td>45.28</td>
<td>24.53</td>
<td>3.84</td>
<td>0.052</td>
</tr>
<tr>
<td></td>
<td>Post 106</td>
<td>0</td>
<td>6.60</td>
<td>16.98</td>
<td>37.74</td>
<td>38.68</td>
<td>4.09</td>
<td></td>
</tr>
<tr>
<td>3. Reliable method of instruction in my course</td>
<td>Pre 106</td>
<td>0</td>
<td>4.72</td>
<td>25.47</td>
<td>53.77</td>
<td>16.04</td>
<td>3.81</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>Post 106</td>
<td>0</td>
<td>2.83</td>
<td>11.32</td>
<td>49.06</td>
<td>36.79</td>
<td>4.20</td>
<td></td>
</tr>
<tr>
<td>4. Gives me confidence to approach a clinical case</td>
<td>Pre 106</td>
<td>1.89</td>
<td>8.49</td>
<td>31.13</td>
<td>42.45</td>
<td>16.04</td>
<td>3.62</td>
<td>0.001*</td>
</tr>
<tr>
<td></td>
<td>Post 106</td>
<td>0.94</td>
<td>5.66</td>
<td>16.04</td>
<td>54.72</td>
<td>22.64</td>
<td>3.92</td>
<td></td>
</tr>
<tr>
<td>5. Could replace a real-case experience when learning how to approach a clinical case</td>
<td>Pre 106</td>
<td>7.55</td>
<td>32.08</td>
<td>29.25</td>
<td>27.36</td>
<td>3.77</td>
<td>2.88</td>
<td>0.978</td>
</tr>
<tr>
<td></td>
<td>Post 106</td>
<td>12.26</td>
<td>31.13</td>
<td>20.75</td>
<td>25.47</td>
<td>10.38</td>
<td>2.91</td>
<td></td>
</tr>
<tr>
<td>6. Is a good bridge between traditional lecture-based teaching and learning from a real case</td>
<td>Pre 106</td>
<td>0</td>
<td>4.72</td>
<td>14.15</td>
<td>53.77</td>
<td>27.36</td>
<td>4.04</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>Post 106</td>
<td>0</td>
<td>0</td>
<td>4.72</td>
<td>43.40</td>
<td>51.89</td>
<td>4.47</td>
<td></td>
</tr>
</tbody>
</table>

### Perceived enjoyment using the CBEL tool

<table>
<thead>
<tr>
<th>Perceived enjoyment</th>
<th>N</th>
<th>SD (%)</th>
<th>D (%)</th>
<th>N (%)</th>
<th>A (%)</th>
<th>SA (%)</th>
<th>Mean</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Approach a clinical case</td>
<td>Pre 106</td>
<td>0.94</td>
<td>4.72</td>
<td>16.98</td>
<td>59.43</td>
<td>17.92</td>
<td>3.89</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>Post 106</td>
<td>0.94</td>
<td>0.94</td>
<td>8.49</td>
<td>39.62</td>
<td>50.00</td>
<td>4.37</td>
<td></td>
</tr>
<tr>
<td>2. Apply my textbook knowledge (what you learn in lectures)</td>
<td>Pre 106</td>
<td>0</td>
<td>0</td>
<td>15.24</td>
<td>47.62</td>
<td>32.38</td>
<td>4.08</td>
<td>0.001*</td>
</tr>
<tr>
<td></td>
<td>Post 106</td>
<td>0</td>
<td>1.89</td>
<td>5.66</td>
<td>46.23</td>
<td>46.23</td>
<td>4.37</td>
<td></td>
</tr>
<tr>
<td>3. Apply my clinical knowledge (what you learn in practice)</td>
<td>Pre 106</td>
<td>0</td>
<td>2.83</td>
<td>13.21</td>
<td>53.77</td>
<td>30.19</td>
<td>4.11</td>
<td>0.003*</td>
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<tr>
<td></td>
<td>Post 106</td>
<td>0</td>
<td>1.89</td>
<td>5.72</td>
<td>47.17</td>
<td>46.23</td>
<td>4.37</td>
<td></td>
</tr>
<tr>
<td>4. Confident using a CBEL tool in my learning</td>
<td>Pre 106</td>
<td>0.94</td>
<td>8.49</td>
<td>29.25</td>
<td>46.23</td>
<td>15.09</td>
<td>3.66</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>Post 106</td>
<td>0.94</td>
<td>0.94</td>
<td>4.72</td>
<td>47.17</td>
<td>46.23</td>
<td>4.37</td>
<td></td>
</tr>
<tr>
<td>5. Confident learning from content presented online</td>
<td>Pre 106</td>
<td>2.83</td>
<td>9.43</td>
<td>24.53</td>
<td>42.45</td>
<td>20.75</td>
<td>3.69</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>Post 106</td>
<td>0</td>
<td>0.94</td>
<td>14.15</td>
<td>42.45</td>
<td>42.45</td>
<td>4.26</td>
<td></td>
</tr>
</tbody>
</table>

Likert-scale item measurements: 1 (SD = Strongly Disagree), 2 (D = Disagree), 3 (N = Neutral), 4 (A = Agree), 5 (SA = Strongly Agree). Mean pre- and post-questionnaire responses of each item were compared using the nonparametric Wilcoxon signed-rank test. Data are expressed as % of the respondents to both questionnaires. *p≤0.05.
LIST OF FIGURES

Figure 2.1: Screenshot of a differential diagnoses slide from a case-based e-learning (CBEL) tool used in a second-year clinical medicine course.
**Figure 2.1:** Screenshot of a differential diagnoses slide from a case-based e-learning (CBEL) tool used in a second-year clinical medicine course.

Bronchitis is inflammation within the epithelial lining of the lower airways. This can develop due to a number of causes, including allergies, bacteria or viruses. 

**Risk Factors:** aggravated by environments where animal is exposed to irritants such as smoke, allergens or dust

**Clinical Presentation:** hacking cough, cough aggravated by exercise, cough involving expectoration of mucus 

**Physical Exam:** lung crackles, cough elicited by tracheal pressure, tachypnea

**Diagnostics to Consider:** radiographs, bronchoscopy, bronchoalveolar lavage +/- culture

Note: not all conditions from the previous slide are discussed here. These are the most probable differentials given that he is an otherwise healthy, vaccinated dog but do not exclude other options if the case work up makes them probable.
CHAPTER THREE

Evaluating perceived effectiveness, clinical confidence, and preferred learning behaviour in the use of a case-based e-learning tool at the Ontario Veterinary College

Chapter submitted for publication and under review in the *Journal of Veterinary Medical Education*. Michael Sawras, Deep Khosa, Kerry Lissemore, Todd Duffield, Alice Defarges.
Abstract

Many case-based e-learning (CBEL) studies in human and veterinary medical education focus on evaluating learning outcomes after the use of an educational intervention to determine its effectiveness. Although important, understanding the impact of students’ learning preferences should also be considered. Evaluating this relationship may offer detailed insight into how CBEL impacts different learners, which in turn may provide insight into how to appropriately implement and design CBEL interventions in veterinary medical education. This study investigated perceived effectiveness, clinical confidence, and impact of perceived learning preferences of veterinary students when using a CBEL tool. Through the use of focus groups as well as pre- and post-use questionnaires, students expressed their perception of the CBEL tool as highly effective in both achieving CBEL outcomes as well as teaching a methodical approach to a clinical case. CBEL learning outcomes were also shown to increase clinical confidence after CBEL use. These findings support the notion that CBEL may be an effective method of creating a bridge between lecture and live animal practice. In addition, exploration of students’ preferred approach to learning revealed that hands on learners and those who prefer to learn by practicing and applying knowledge were more likely to show positive perceptions of a CBEL tool, suggesting that learning styles may play a role in its use and effectiveness. The results of this study indicate that CBEL may be a viable learning modality and provide a platform for further exploration of the effectiveness and use of this CBEL in veterinary medical education.

Key words: case-based e-learning, e-learning, case-based learning, blended learning, virtual patients, electronic cases, clinical reasoning, learning styles, learning behavior
Introduction

In clinical medicine, the challenge exists to provide students with a foundation of the necessary knowledge, skills and attributes needed to be able to undertake clinical cases. In medical and veterinary education, deep learning is desirable as it prioritizes understanding over memorization and aims to integrate concepts across disciplines to broaden the understanding of a given topic (Allenspach et al., 2008; Monahan & Yew, 2002; Newble & Entwistle, 1986). This is especially important in creating a link between theoretical knowledge and clinical application as well as helping with the understanding of complex, interrelated concepts that are typically present within clinical cases (Allenspach et al., 2008; Monahan & Yew, 2002; Newble & Entwistle, 1986). In order to promote deep learning, student-centered, inquiry-based learning modalities such as case-based learning (CBL) have been widely introduced in medical and veterinary medical education (Eurell et al., 1999; Fajt et al., 2009; Krockenberger et al., 2007; Patterson, 2006; Pickrell et al., 2002; Sharkey et al., 2007, 2012).

Although CBL has been shown to promote the development of clinical reasoning, critical thinking and problem solving proficiencies (DeSanto-Madeya, 2007), various challenges have been identified that may hinder its use and effectiveness. In healthcare education particularly, providing realistic or hands-on learning opportunities for students to apply theoretical knowledge in a clinical setting may be difficult to achieve and depend heavily on resource availability. Often, students find it challenging to bridge the gap between the clinical content they were taught in lecture and what they experience through observation and participation in real-world clinical decision making (May, 2013). Students may also demonstrate a lack of confidence in their ability to apply clinical knowledge learned in the classroom to real clinical cases that require a holistic
view of a patient (May, 2013). Case-based e-learning (CBEL) has been identified as a promising solution to address these challenges (Rowe et al., 2012; Ruiz et al., 2006). CBEL harnesses the benefits of e-learning such as increased accessibility, convenience, and interactivity (Ellaway & Masters, 2008) to create a bridge between lecture material and live animal practice which gives students a safe space to practice approaching a clinical case and applying clinical concepts to clinical cases before encountering scenarios in real life. CBEL also provides students with the ability to learn a methodical approach to a clinical case, reinforcing the structure behind sound decision making and maneuvering through a live case. Finally, CBEL can standardize learning content among all students which helps to ensure all students are achieving the same pre-determined learning outcomes (Ellaway & Masters, 2008).

CBEL has been extensively implemented and studied in human medical education. Typically, its use has produced positive results, especially when used in a blended learning environment with traditional didactic lectures (Rowe et al., 2012; Ruiz et al., 2006). CBEL has been less investigated in veterinary medical education, but, has similarly shown positive reports including enhancing the quality of the clinical learning experience (Trace et al., 2012), increasing motivation for a subject (Kleinsorgen et al., 2018), and improving clinical decision making skills by facilitating students’ transition from problem solving in a well-structured classroom setting to an ill-structured clinical setting (Creevy et al., 2017).

Many CBEL studies in human and veterinary medical education focus on evaluating learning outcomes after the use of an educational intervention to determine its effectiveness (Creevy et al., 2017; Gaupp et al., 2016; Howlett et al., 2009; Kandasamy & Fung, 2009; Kleinsorgen et al., 2017, 2018; S. Kolb et al., 2009). Although important, understanding the
impact of students’ learning preferences during the use of a new instructional intervention is also essential for the design and appropriate implementation of teaching innovations in order to maximize their learning effectiveness (Choi et al., 2009). Conflicting research has been reported in human medical education regarding the impact of learning styles on perceptions and effectiveness of CBEL with some indicating that learning styles play a role early in the implementation of a CBEL environment (Choi et al., 2009), while others indicate that learning styles do not influence learning outcomes with web-based interventions (Cook et al., 2007). However, some research in veterinary medical education indicates that different learning styles are associated with specific skill sets which may dictate the success of various teaching interventions (Ryan et al., 2004).

To our knowledge, to date there have been no studies that explore the relationship between perceived learning preferences of veterinary students and the use of CBEL. Evaluating this relationship may offer detailed insight into how CBEL impacts different learners, which in turn provides insight into how to appropriately implement and design case-based e-learning interventions in veterinary medical education.

Case based e-learning was implemented in a second-year clinical medicine course at the Ontario Veterinary College (OVC). Online cases depicting common clinical problems were developed using Articulate Storyline 2®, an e-learning development tool. Online cases were implemented to help students apply clinical knowledge to realistic case-based scenarios, and to assist in teaching a methodical approach to a clinical case.
The aims of this study were to evaluate students’ perceived effectiveness of a CBEL tool; measure students’ self-confidence in application and use of clinical knowledge and skills when using a CBEL tool and explore the relationship between perceived learning preferences of veterinary students and the use of CBEL.

**Methods**

*Study Design and Participants*

Using an exploratory mixed-methods design, focus group discussions subsequently informed the design of pre- and post- case-based e-learning use questionnaires delivered to second-year Doctor of Veterinary Medicine (DVM) students. Students received a gift card honorarium and a meal for participating in the focus groups or inclusion into gift card draws for completing each questionnaire. Participation in the study was voluntary and there was no impact on course grades. All students gave written informed consent to participate in the study. The study was approved by the Research and Ethics Board at the University of Guelph (REB#17-01-009).

*Research Setting*

A second-year clinical medicine DVM course at the Ontario Veterinary College (OVC), University of Guelph, Canada served as the primary research setting for this study. The lecture- and lab-based course is designed as a blended learning environment and requires students to learn about common presenting problems and the associated pathophysiological disease processes. The lab component of the course provides students the opportunity to apply
knowledge learned in lectures through the use of online case-based material presented in the form of e-learning. Each lab session focuses on a different presenting problem as taught in lectures. Five different small animal cases were available for each presenting problem discussed in lectures. For example, five cases are made available for the presenting problem of vomiting and were housed on the University of Guelph’s learning management system, CourseLink™. Four groups, each consisting of 31 students attend a lab time per group and are given the opportunity to work collaboratively or individually on the online cases available to them. Students are required to pick one case to investigate further and submit a medical record assignment based on that case. Completion of all cases is not mandatory but is encouraged. Teaching faculty are present in lab sessions to answer any questions that arise in relation to the cases or lecture material. All cases were made available to all students for the duration of the course.

*e-Learning Platform Articulate Storyline 2®*

The e-learning tool *Articulate Storyline 2®* is an online platform specifically designed for creating, distributing and evaluating interactive courses, and was used for all cases in this project. Each case presents a realistic scenario involving a patient presenting for a medical complaint and navigates the student through: history taking; doing a physical exam; creating problem lists; selecting investigatory tests and procedures; developing a treatment plan; and follow up considerations. Cases were optimized to present information as realistically as possible and to minimize logistical technical complications, ensuring that the focus is on learning the process of navigating a clinical case and applying lecture knowledge. Cases were designed based on the principles of outcome-based education where the desired learning outcome for each case
was decided upon first, and then the case was specifically constructed to meet the set learning outcome. Each case took approximately eight to ten hours to design, build and implement for the course. Cases were designed with radio buttons, check boxes or click and drag options implemented at each clinical step to simulate a decision-making process. If incorrect options are selected, feedback is typically provided in the cases in the form of a pop-up message box, with explanations provided as to why this may be the case. Various clinical steps (e.g. differential diagnosis) include text boxes, either embedded or that appear when hovering over an option. Text boxes provide important clinical knowledge that explain in more detail the rationale required in the particular clinical step or the pathophysiological manifestations of the presenting problem.

*Data Collection*

Focus Group and Interview Structure

Focus groups and a single one-on-one interview were conducted by the first author with the graduating class of 2019 between March and May 2017, at the OVC. This class was chosen for focus groups as they were given the opportunity to use the CBEL tool in the clinical medicine course throughout the 2016/2017 academic year. An interview guide was used in all discussions that consisted of four main topics: usability; students' satisfaction; perceived effectiveness in students’ learning; and overall assessment of the case-based e-learning tool including recommendations for its use in veterinary education. Discussions were audio recorded, transcribed verbatim, and de-identified.
Pre- and Post-use Questionnaires

Two matched questionnaires were designed using results from the focus group discussions and included questions about participant demographics as well as specific topics of learning behaviour and perceptions of CBEL such as: learning preferences; perceived effectiveness of achieving learning outcomes through CBEL-use; perceived effectiveness of a CBEL tool in learning a methodical approach to a clinical case; and to what extent various factors of using a CBEL tool may increase their clinical confidence. Both questionnaires were delivered online from October 2017 to March 2018 to the graduating class of 2020 through the Qualtrics® survey tool. This class was given the opportunity to use the CBEL tool in their second-year clinical medicine course throughout the 2017/2018 academic year. There were no curricular changes between the 2016/2017 and 2017/2018 academic years.

The pre-CBEL use questionnaire was delivered in the first lab session of the course to determine students’ preliminary perceptions about CBEL prior to its use. An introductory presentation about the labs as well as the use, purpose and rationale behind case-based e-learning was also provided in the first session. Students were given time to access and complete the questionnaire in the first lab. The post-use questionnaire was delivered one week after completion of the course.
Data Analysis

Qualitative Data

Transcripts were analyzed using thematic analysis (Braun & Clarke, 2006). This involves repeated listening of audio recordings and reading of verbatim transcripts to allow for familiarization of data, examining transcripts line-by-line, and assigning codes. Codes were checked and reviewed, and similar concepts were grouped into categories to identify initial themes and subthemes. Themes were then revisited, refined, defined for clarity and accuracy, and explored to establish any interrelated relationships and connections.

Quantitative Data

All pre- and post- questionnaire data analysis was conducted using SAS 9.4 (SAS Institute Inc., Cary, NC, USA). Pre- and post-use scores between students were compared using the nonparametric Wilcoxon signed-rank tests for all questions containing Likert or ranked data due to the assumption that all data was non-normally distributed. Spearman rank-order correlations were conducted to determine if there were any relationships between perceived learning preferences and the outcomes measured. Spearman’s rho (\( r_s \)) coefficient and p value are reported for any significant correlations. Significance level for all statistical tests was set at p≤0.05. Demographics were analyzed using descriptive statistics.
Results

Questionnaire Quantitative Data

Response Rate and Demographics

One hundred and eighteen second-year veterinary students out of 124 (95%) enrolled in their cohort completed the pre-use questionnaire. One hundred and nine students completed the post-use questionnaire (87.9%), of which, one hundred and six completed both questionnaires (85.5%). The study cohort is comprised of these 106 students. 98% of respondents were female, which was representative of the 94% female distribution of the graduating class of 2020 at the OVC. Mean age of respondents at the time of the pre-questionnaire was 24.1 years with majority of students hoping to enter mixed animal (48%) or small animal (41%) practice in the future.

Student Learning Preferences

Students reported learning best by practicing and applying knowledge (M = 4.56) with 95.76% of students either agreeing or strongly agreeing with this statement. This was followed closely by hands-on learning (M = 4.01) and learning visually through pictures and videos (M = 3.99). Students identified least with preferring to learn in a group (M = 2.77) and that they preferred working through the online cases on their own (M = 3.97). This was further supported with agreement that they learned successfully because they could work at their own pace (M = 4.26). However, students also indicated that they learned successfully because they could work through the cases with the support of their peers (M = 3.47). Overall, students generally indicated
that they believed the CBEL tool would satisfy their own perceived learning style (M = 3.98) with 80.19% of students either agreeing or strongly agreeing with this statement (Table 3.1).

Perceived Effectiveness of Achieving Learning Outcomes Through CBEL Use

Students reported mean scores greater than 3.43/5 in both the pre- and post-questionnaires in all perceived CBEL learning outcomes (Table 3.2). Most mean scores increased in the post-questionnaire, with significant changes seen in agreement that a CBEL tool would challenge students to apply previous knowledge to a real case scenario (p = 0.003) as well as assist in learning efficiently (p = 0.005). Non-significant decreases in mean score was seen in agreement that a CBEL tool would motivate one to explore clinical topics in more depth and improve decision making accuracy, although post-questionnaire scores of M = 3.76 and M = 3.75, respectively, were reported. Integration of knowledge from various courses to solve a clinical case (M = 4.284), significantly increased from the pre-use (M = 4.13) to post-use (M = 4.29) questionnaire (p = 0.026). The greatest difference in mean score corresponded to being a good study tool for future courses, which significantly increased from 3.62/5 to 4.03/5 (p<0.001).

Perceived Effectiveness of Learning a Methodical Approach to a Clinical Case through CBEL Use

Mean scores positively increased in the post-use questionnaires for all items regarding approaching a clinical case, with 3 of the 7 significantly increasing. The lowest scores reported in the post-use questionnaire were understanding a physical exam (M = 3.93) and following up with a patient’s treatment plan (M = 3.82). Students agreed that the CBEL tool effectively taught
how to create a problem list, with 93.40% agreeing or strongly agreeing with this statement. The most significant increase was in deciding which diagnostics are most appropriate, with mean score increasing from 4.09 to 4.36 (p<0.001) after CBEL-use (Table 3.3).

Clinical Confidence

All but one confidence statement decreased in the post-questionnaire, although all were non-significant. Students reported the lowest scores in the statements describing confidence from retaining knowledge (M = 6.65) and confidence from demonstrating veterinary competencies (M = 6.83). All other statements had a mean score of 7.31/10 or greater, with the highest mean score represented by learning the process of a clinical case (M = 7.77) (Table 3.4).

Correlating Perceived Learning Preferences with Perceived Effectiveness and Clinical Confidence

Overall mean scores were taken for each of the following outcomes: Perceived effectiveness of achieving CBEL outcomes; Perceived effectiveness of teaching a methodical approach to a clinical case; and Clinical confidence (Table 3.5). Each outcome was comprised of all corresponding questionnaire items. A significant increase was seen in perceived effectiveness of a CBEL in learning a methodical approach to a clinical case (Mean diff = +0.160, p = 0.0173). Clinical confidence and perceived effectiveness of achieving CBEL outcomes slightly decreased, however, non-significantly.

Spearman correlation with two-tailed test of significance indicated that there was significant correlation between learning best by practicing and applying knowledge and
perceived effectiveness of learning how to approach a clinical case \( (r_s = 0.288, p = 0.003) \).

Significant correlations were also observed between hands on learners and perceived effectiveness of achieving CBEL outcomes \( (r_s = 0.297, p = 0.002) \), perceived effectiveness of learning how to approach a clinical case \( (r_s = 0.233, p = 0.016) \), and clinical confidence \( (r_s = 0.228, p = 0.019) \) (Table 3.6).

**Focus Group Qualitative Data**

**Theme 1: Understanding vs. Memorization**

Many students discussed the ability to apply and integrate knowledge while using the CBEL tool, which in turn promoted understanding clinical knowledge over memorization. One student summarized this idea by explaining that the online cases provide context to different clinical scenarios and creates an opportunity to connect these experiences to what was learned in lecture:

P05: “It just gives you more context on the information that we’re learning in all of our classes…That way, whenever we’re out shadowing, you feel more like you understand what they’re doing…and you can connect it back to all the stuff you learned through these modules…You have this bigger picture that all this new information can be added on top of.”

One student similarly indicated that different topics are integrated into a case which helps understand the full picture as opposed to smaller pieces that are taught separately in the course by generating a “thinking process” of how to approach a clinical case:
P06: “I think the most valuable part of these [online cases] is that there’s a thinking process to it. If we could do a little more of these that are really integrated amongst other topics, I think it would be really beneficial to start pulling together a whole story context instead of these tiny little pieces we see in different places.”

Other students reinforced this notion by explaining that because the online cases incorporated information from other courses, they also felt more confident in those courses:

P04: “[The clinical medicine course] is supposed to bring everything together and these modules definitely do that. What I learned in all these other courses, you go through this module and it’s all there [and] it actually makes sense. [The online cases] weren’t so narrow[ly] focused, it was very broad, integrating information. It definitely made you feel a lot more confident about the other courses…”

P11: “I felt like [the online cases] engaged my problem solving [skills], whereas in a normal class setting I’d be sitting and listening. They would tell me these are the differentials, where here, I actually have to think about them myself so I feel like that’s challenging me more…I think the [online cases] give you the option to use those skills to work through the case.”

Many students explained that one way the online cases created a problem solving environment was by showing an entire clinical case from start to finish. This created the opportunity to follow an entire case which can be challenging because “in the clinic a lot of the time you go in and you’re not able to follow a case from start to finish because sometimes you
leave and you come back the next day and the patient is gone (P11).” One student explained the benefits of this, stating that “it helped figure out what to do next instead of not knowing the order of doing things (P06)” and further commented that “you have to take the important things and then move on from each step, so that helps (P06).”

Similarly, critical thinking was also mentioned as a skill that the online cases helped develop. One student highlighted that without being able to critically think about a case, there may be consequences to decisions you make:

P02: “People want the quick fix, but if you don’t understand what you’re doing, you’re going to end up doing it wrong sometimes and you might end up in real trouble. These modules actually teach you the how and why you’re doing what you’re doing.”

P05: “Going through some of the modules, [they] tell you what’s wrong [and] why that was the wrong answer…So…I would click on [an answer] and say it’s wrong because of this and then it would say actually it’s wrong because of that. It’s a way to test everything within [a case], with all the different options.”

Students mentioned that the online cases helped them learn the process of how to approach a clinical case, however, indicated that the online cases did not help learn the content in the course: “I wouldn’t say that it actually helped me learn the content. It was more the process of how you get from history to problem list to what tests you’re going to run to a diagnosis to treatment (P09).” Other students disagreed and explained that the online cases led them to alter their approach to learning clinical information, moving away from primarily memorization.
Some cited the audio/visual elements of the clinical cases as helpful pieces for knowledge retention with one student indicating that they were able to visualize the online cases after using them and use this to help associate the appropriate clinical concepts:

P04: “I was always the guy that memorized, memorized, memorized and it was so easy to do it all on a test, but then you’d ask me something two days after the test and I’d have no idea what it was anymore… when you hit vet school you can no longer do that. I can’t close my eyes now and remember a lecture note that I read but I can close my eyes and see the cases I worked through. It just sticks, I don’t know why, but it just sticks and working through [the online cases] is definitely [more] helpful rather than reading.”

Theme 2: Clinical Confidence

Students explained that by making decisions in the online clinical cases “it was nice to get some confidence so that you could maybe work through a simple case start to finish by yourself (P06).” One student summarized their peers by explaining that although the details of clinical cases change between patients, the process to approach and solve each case stays relatively similar. They explained that by practicing these steps and learning in a case-based context, you feel more confident in your abilities in new or stressful situations:

P05: “I think even if the scenario you’re working on isn’t the same as any of the scenarios you’ve done before, the process from step A to Z is the same for every case… I think the more times we get to practice that process from beginning to end… I think it would be beneficial to do as you continue with your learning
because it gives you more context for when you are in a similar situation…it just

gives you more confidence in what you’re doing in that heat of the moment
situation.”

Students indicating that at this stage of their education, they do not get to make any
decisions while in the clinic, however, these online cases provide the opportunity to do so which
allows them to demonstrate some of their veterinary competencies: “In the clinic, you’re not
really engaged in the problem solving as much, you don’t get to make the decisions, whereas
using the online modules you are so you feel like you’re a real vet (P11).” Another student
expanded on this point, explaining they were more comfortable approaching a clinical case and
that they could contribute more than they previously felt they were able to:

P03: “I feel like after doing these modules I feel a lot more comfortable. Maybe
not diagnosing something, but taking the original problem a step further and
saying ‘okay well it coughs so we’re going to do this test’. Maybe at that point
I’m not the best at interpreting the results but I feel confident that I can take it a
step further than I could have before this.”

Finally, one student suggested incorporating online cases into the curriculum as early as
possible to help with confidence:

P11: “As a vet student, you feel like you’re really unprepared 99% of the time
[group laughter]. You’re learning all these things but you don’t really know how
to apply it yet…I think if we try to incorporate the process of problem solving and
the process of how to solve a case as early as possible in the curriculum, it would
be very beneficial in making vet students feel confident in their abilities, like they’re actually on the road to becoming a successful vet.”

Discussion

Overall, students felt the online tool was highly effective at achieving CBEL outcomes in the course, as well as facilitating developing a methodical approach to a clinical case. Students also reported positive perceptions with all aspects of a CBEL tool that may influence clinical confidence. Those who preferred to learn through practicing and applying as well as with hands-on activities showed significantly positive correlations with perceived effectiveness of the CBEL tool, as well as with clinical confidence. Contrarily, those who prefer to read and memorize, work in a group, and learn visually did not show any significant correlations.

Students reported the CBEL tool prioritized understanding over memorization. Specifically, it was expressed in the focus groups that the online cases challenged their problem solving and critical thinking abilities. In turn, this helped provide context to clinical knowledge learned in lecture as well as insight into when to apply this knowledge in a clinical case. The high scores reported in each step of the approach to a clinical case supports this notion and demonstrates the value students placed in the CBEL tool not only when learning how to approach clinical steps individually, but also how to approach a clinical case as a whole. This being said, students reported that the CBEL tool most effectively taught them how to decide which diagnostics were most appropriate. In turn, CBEL may be useful for a targeted approach to let students explore diagnostics and the appropriateness of their use in clinical cases. Students also indicated that it was helpful to practice applying lecture knowledge and explore the repercussions of various
decisions in a case because this prompted an understanding of why these decisions were made, which in turn, helped them remember clinical concepts and scenarios. High pre-questionnaire scores may account for non-significant changes in many CBEL outcomes as well as some decreases from the pre-questionnaire to the post-questionnaire. Although the online cases were simply described for their purpose in the course, there is a possibility that when introducing these cases, the students may have interpreted this introduction as a positive explanation of these cases. In this case, the high pre-use scores may be a function of premeditated positive perceptions of CBEL. Given that most scores remained high after the post-questionnaire, we can conclude that students perceived the CBEL tool to be effective at achieving CBEL outcomes and methodically approaching a clinical case. Other CBEL studies in veterinary medical education indicate similar findings. Creevy et al. (2007) evaluated the use of expert feedback in a CBEL tool and its effect on decision making skills. The authors concluded that the ability to rehearse clinical decision making through this tool may facilitate and improve students’ problem solving and decision making competencies from a structured classroom space to an unstructured clinical environment. Similarly, Kleinsorgen et al. (2018) evaluated the impact of optional online cases on learning progress and success in a biochemistry course. The authors demonstrated a weak correlation between performance in the online cases and performance in final exams, however, concluded that the online cases increased student motivation in the subject of biochemistry. While beyond the objectives of this present study, further research measuring outcomes such as clinical decision-making skills would provide more evidence of the effect CBEL has on applying clinical knowledge in clinical scenarios. Furthermore, this type of evaluation would help validate the return on investment of implementing CBEL in veterinary medical education when compared to
other teaching modalities. A longitudinal study following a student cohort exposed to CBEL may provide more insight to the long-term effects of this learning modality.

The opportunity to practice may result in increased confidence in a clinical setting when applying knowledge and skills learned using CBEL. Patterson (2006) previously demonstrated that increased confidence resulted in improved clinical reasoning skills after CBL. In the questionnaires, students in this study rated all but two clinical confidence statement highly. Surprisingly, one item was demonstrating veterinary competencies. In the focus groups, students indicated that the CBEL tool increased comfort when approaching a clinical case and made them feel closer to being a veterinarian, which contradicts the questionnaire results. This might mean that students in the focus groups were potentially referring to learning outcomes such as application of knowledge, navigating through and learning the process of a clinical case, as well as practicing critical thinking and problem solving when discussing their feelings of preparedness in veterinary medicine, and less to clinical or technical competencies that are more tactile in nature. Winder et al. (2017) reports similar findings by explaining that online resources may not necessarily be as beneficial with regards to technical skill training, however, the authors did state that they may be beneficial when used in addition to hands-on practice. Although it seems promising that a CBEL tool may increase clinical confidence, an increase in confidence does not necessarily directly result in an increase in competence. Some evidence shows that confidence has little predictive value on future assessments using clinical scenarios (Morgan & Cleave-Hogg, 2002). Future studies should evaluate the relationship between confidence and competence in knowledge and application of clinical concepts after CBEL-use to determine the true effectiveness of CBEL in veterinary medical education.
We set out to explore whether there was any relationship between perceived personal learning preferences on perceptions of CBEL to understand if learning preferences should be considered when designing and delivering CBEL. Our results indicate that students who prefer hands-on learning perceived CBEL to be more effective at achieving learning outcomes, learning how to methodically approach a clinical case, and higher perceived clinical confidence after CBEL use. Those who prefer to practice and apply their knowledge also perceived CBEL to be more effective at learning how to methodically approach a clinical case. Since the researchers in this study were exploring the relationship between learning preferences and CBEL-use, we did not employ a validated learning style inventory which may provide more evidence that is comparable to the existing literature. There is conflicting research with regards to how student learning styles impact their learning experience when new educational interventions are implemented. Choi, Lee and Kang (2009) found that students with an active-reflexive learning style performed slightly better on tests earlier than other students, however, over time, this difference became negligible. Other research indicates that learning styles do not influence learning outcomes in web-based learning modalities (Cook et al., 2007). Further research should be conducted in veterinary medical education using a validated learning style inventory such as the Myers-Briggs type model (Myers et al., 1998), Kolb’s learning style model (D. Kolb, 1985), and the Felder-Silverman learning style model (Felder, 1993) in order to determine the impact of learning styles in a CBEL environment in order to build from and validate the results reported in this study.

Approximately 96% of students either agreed or strongly agreed that they preferred to practice and apply their knowledge when learning. The fact that majority of students identified
with this learning preference and that it showed a significantly positive correlation with perceptions of effectiveness, allows us to conclude that CBEL may be a viable teaching modality in veterinary medical education. However, significant correlations were not seen in any outcome with visual learners, those who prefer to read and memorize, nor those who prefer to work in groups. Current educational interventions in veterinary medicine attempt to persuade students to avoid surface approaches such as reading and memorizing (Ryan et al., 2004) which typically appeal to collaborative and visual learners. Therefore, it was surprising to see that collaborative and visual learners were less likely to perceive the CBEL tool as effective. Previous studies conducted in human medical education reported that students highly valued the realism of online cases (Issenberg et al., 2005; Huwendiek et al., 2009; Jin & Bridges, 2014). The low-fidelity nature of the visual elements of our cases may explain the unexpectedly poor relationship observed with visual learners. Additionally, Ellaway & Masters (2008) reported the idea that the integration of technology and online learning into traditional curricula supports and encourages the capacity to communicate and collaborate with peers. Interestingly, the students in this study reported contradicting evidence as they indicated that the CBEL tool motivated them to interact with their peers when working through a case as a group, but that the CBEL tool also promoted working independently on the online cases. Future research should explore the social dynamics of the use of a CBEL tool in veterinary medical education in order to determine how to appeal to those who prefer to learn in a group, and to investigate how to successfully engage in a collaborative learning environment when using CBEL.
Limitations

This study measured self-reported perceptions towards CBEL use in a clinical medicine course with students who are still early in their veterinary medicine program. These perceptions may differ in cohorts that are more experienced in veterinary medicine and are further along in their program. Additionally, the lack of a comparison group limits the ability to determine if the reported results differ from other learning modalities such as CBEL-use outside of a blended learning environment, traditional didactic lectures, or non-electronic CBL. Only short-term effects can be detected in a within-subject design with pre- and post-use evaluation. Repeated measures and longer follow-up timeframes may be necessary to evaluate long-term perceptions. A single-centre study limits generalizability of results. There is a possibility of bias as a result of students having positive perceptions of the clinical medicine course or from student excitement in using a new learning modality in the course. This may result in inflated positive results, particularly in the pre-use questionnaire. Finally, there is a risk of selection bias due to the voluntary nature of the research and the chance that those who were more motivated in the course may have chosen to participate. The high response rate in the study may negate this.

Conclusion

Our results indicate that CBEL is a viable learning modality in veterinary medical education. Students perceived the CBEL tool as highly effective in both achieving CBEL outcomes as well as teaching a methodical approach to a clinical case. Various CBEL learning outcomes were also shown to increase clinical confidence after CBEL use. These findings support the notion that CBEL may be an effective method of creating a bridge between lecture
and live animal practice, providing students with a safe space to explore relationships between clinical concepts, practice applying clinical knowledge in a controlled setting, and understand the necessary steps and decisions required when treating a live animal. In addition, exploration of students’ preferred approach to learning revealed that hands on learners and those who prefer to learn by practicing and applying knowledge were more likely to show positive perceptions of the CBEL tool, suggesting that learning styles may play a role in the use and effectiveness of a CBEL tool. The results of this study provide a platform for further exploration of the effectiveness and use of this CBEL in veterinary medical education.

Notes

i. Articulate Storyline 2, Articulate Global, Inc., New York, NY, USA

ii. CourseLink, University of Guelph, Guelph, ON, Canada

iii. Qualtrics Survey Software, Qualtrics LLC, Provo, UT, USA

iv. SAS 9.4, SAS Institute Inc., Cary, NC, USA
REFERENCES


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Table 3.1: Student’s responses to questions regarding their perceived learning preferences when using a CBEL tool in a second-year clinical medicine course. Frequency distribution and mean score of students’ perceptions are reported, pre- and post-CBEL use.

Table 3.2: Student’s responses to questions regarding the perceived effectiveness of a CBEL tool in achieving various learning outcomes in a second-year clinical medicine course. Frequency distribution, mean score, and significance of students’ perceptions are reported, pre- and post-CBEL use, using the nonparametric Wilcoxon signed-rank test.

Table 3.3: Student’s responses to questions regarding the perceived effectiveness of a CBEL tool in teaching a methodical approach to a clinical case, used in a second-year clinical medicine course. Frequency distribution, mean score, and significance of students’ perceptions are reported, pre- and post-CBEL use, using the nonparametric Wilcoxon signed-rank test.

Table 3.4: Students’ responses to questions regarding the extent in which various CBEL learning outcomes may increase clinical confidence in a second-year clinical medicine course. Frequency distribution, mean score, and significance of students’ perceptions are reported, pre- and post-CBEL use, using the nonparametric Wilcoxon signed-rank test.
Table 3.5: Students’ mean responses to pooled questions in the following scales regarding the use of a CBEL tool in a second-year clinical medicine course: perceived effectiveness of achieving CBEL outcomes; perceived effectiveness of teaching a methodical approach to a clinical case; clinical confidence. Mean score and significance of students’ perceptions are reported, pre- and post-CBEL use, using the nonparametric Wilcoxon signed-rank test.

Table 3.6: Spearman correlation of perceived learning preferences from the pre-use questionnaire and measured outcomes from the post-use questionnaire.
**TABLES**

**Table 3.1:** Student’s responses to questions regarding their perceived learning preferences when using a CBEL tool in a second-year clinical medicine course. Frequency distribution and mean score of students’ perceptions are reported, pre- and post-CBEL use.

<table>
<thead>
<tr>
<th>Learning Preferences</th>
<th>N</th>
<th>SD (%)</th>
<th>D (%)</th>
<th>N (%)</th>
<th>A (%)</th>
<th>SA (%)</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Reading and memorizing</td>
<td>Pre</td>
<td>106</td>
<td>6.78</td>
<td>29.66</td>
<td>20.34</td>
<td>37.29</td>
<td>5.93</td>
</tr>
<tr>
<td>2. Practicing and applying knowledge</td>
<td>Pre</td>
<td>106</td>
<td>0</td>
<td>0</td>
<td>4.24</td>
<td>37.29</td>
<td>58.47</td>
</tr>
<tr>
<td>3. Visually through videos and pictures</td>
<td>Pre</td>
<td>106</td>
<td>0.85</td>
<td>7.63</td>
<td>10.17</td>
<td>56.78</td>
<td>24.58</td>
</tr>
<tr>
<td>4. Working in a group</td>
<td>Pre</td>
<td>106</td>
<td>9.32</td>
<td>35.59</td>
<td>27.12</td>
<td>23.73</td>
<td>4.24</td>
</tr>
<tr>
<td>5. I am a hands-on learner and need to work on an actual case to understand clinical concepts</td>
<td>Pre</td>
<td>106</td>
<td>0</td>
<td>7.63</td>
<td>16.95</td>
<td>47.46</td>
<td>27.97</td>
</tr>
<tr>
<td>6. The case-based e-learning tool satisfied my own learning style</td>
<td>Post</td>
<td>106</td>
<td>0</td>
<td>1.89</td>
<td>17.92</td>
<td>60.38</td>
<td>19.81</td>
</tr>
<tr>
<td>7. I preferred to work through the online cases on my own</td>
<td>Post</td>
<td>106</td>
<td>1.89</td>
<td>2.83</td>
<td>20.75</td>
<td>45.28</td>
<td>29.25</td>
</tr>
<tr>
<td>8. I learned successfully because I could work through the cases at my own pace</td>
<td>Post</td>
<td>106</td>
<td>0</td>
<td>0</td>
<td>12.26</td>
<td>49.06</td>
<td>38.68</td>
</tr>
<tr>
<td>9. I learned successfully because I could work through the cases with support from my peers</td>
<td>Post</td>
<td>106</td>
<td>2.83</td>
<td>14.15</td>
<td>35.85</td>
<td>27.36</td>
<td>19.81</td>
</tr>
</tbody>
</table>

Likert-scale item measurements: 1 (SD = Strongly Disagree), 2 (D = Disagree), 3 (N = Neutral), 4 (A = Agree), 5 (SA = Strongly Agree). Data are expressed as % of the 106 respondents to both questionnaires.
Table 3.2: Student’s responses to questions regarding the perceived effectiveness of a CBEL tool in achieving various learning outcomes in a second-year clinical medicine course. Frequency distribution, mean score, and significance of students’ perceptions are reported, pre- and post-CBEL use, using the nonparametric Wilcoxon signed-rank test.

<table>
<thead>
<tr>
<th>Learning Outcomes Through CBEL Use</th>
<th>N</th>
<th>SD (%)</th>
<th>D (%)</th>
<th>N (%)</th>
<th>A (%)</th>
<th>SA (%)</th>
<th>Mean</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Improve my critical thinking skills</td>
<td>Pre</td>
<td>106</td>
<td>0</td>
<td>3.77</td>
<td>21.70</td>
<td>61.32</td>
<td>13.21</td>
<td>3.84</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>106</td>
<td>0</td>
<td>5.66</td>
<td>22.64</td>
<td>58.49</td>
<td>13.21</td>
<td>3.79</td>
</tr>
<tr>
<td>2. Enhance my problem-solving skills</td>
<td>Pre</td>
<td>106</td>
<td>0.94</td>
<td>1.89</td>
<td>15.09</td>
<td>67.92</td>
<td>14.15</td>
<td>3.93</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>106</td>
<td>0</td>
<td>4.72</td>
<td>22.64</td>
<td>57.55</td>
<td>15.09</td>
<td>3.83</td>
</tr>
<tr>
<td>3. Challenge me to apply previous knowledge to a case/problem</td>
<td>Pre</td>
<td>106</td>
<td>0.94</td>
<td>0.94</td>
<td>10.38</td>
<td>60.38</td>
<td>27.36</td>
<td>4.12</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>106</td>
<td>0</td>
<td>0.94</td>
<td>7.55</td>
<td>48.11</td>
<td>43.40</td>
<td>4.34</td>
</tr>
<tr>
<td>4. Allow me to integrate knowledge from various courses to solve a case</td>
<td>Pre</td>
<td>106</td>
<td>0</td>
<td>0</td>
<td>11.32</td>
<td>64.15</td>
<td>24.53</td>
<td>4.13</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>106</td>
<td>0.94</td>
<td>4.72</td>
<td>23.58</td>
<td>48.11</td>
<td>24.53</td>
<td>4.13</td>
</tr>
<tr>
<td>5. Allow me to remember various topics/concepts for a longer period of time</td>
<td>Pre</td>
<td>106</td>
<td>0.94</td>
<td>4.72</td>
<td>23.58</td>
<td>48.11</td>
<td>24.53</td>
<td>4.13</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>106</td>
<td>0.94</td>
<td>3.77</td>
<td>19.81</td>
<td>50.94</td>
<td>24.53</td>
<td>3.94</td>
</tr>
<tr>
<td>6. Help me understand the concepts taught in this course</td>
<td>Pre</td>
<td>106</td>
<td>0.94</td>
<td>0.94</td>
<td>8.49</td>
<td>71.70</td>
<td>17.92</td>
<td>4.05</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>106</td>
<td>0</td>
<td>1.89</td>
<td>5.66</td>
<td>61.32</td>
<td>31.13</td>
<td>4.22</td>
</tr>
<tr>
<td>7. Help me understand concepts rather than memorizing them</td>
<td>Pre</td>
<td>106</td>
<td>0</td>
<td>2.83</td>
<td>9.43</td>
<td>62.26</td>
<td>25.47</td>
<td>4.10</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>106</td>
<td>0</td>
<td>3.77</td>
<td>8.49</td>
<td>53.77</td>
<td>33.96</td>
<td>4.18</td>
</tr>
<tr>
<td>8. Assist in learning efficiently in the time I have</td>
<td>Pre</td>
<td>106</td>
<td>1.89</td>
<td>9.43</td>
<td>30.19</td>
<td>45.28</td>
<td>13.21</td>
<td>3.59</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>106</td>
<td>0.94</td>
<td>8.49</td>
<td>9.43</td>
<td>45.28</td>
<td>33.96</td>
<td>4.18</td>
</tr>
<tr>
<td>9. Motivate me to interact with my peers when working through a case as a group</td>
<td>Pre</td>
<td>106</td>
<td>2.83</td>
<td>17.92</td>
<td>22.64</td>
<td>46.23</td>
<td>10.38</td>
<td>3.43</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>106</td>
<td>3.77</td>
<td>16.04</td>
<td>24.53</td>
<td>32.08</td>
<td>23.58</td>
<td>3.56</td>
</tr>
<tr>
<td>10. Promote working independently on the online cases</td>
<td>Pre</td>
<td>106</td>
<td>0</td>
<td>11.32</td>
<td>27.36</td>
<td>49.06</td>
<td>12.26</td>
<td>3.62</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>106</td>
<td>0.94</td>
<td>6.60</td>
<td>21.70</td>
<td>40.57</td>
<td>30.19</td>
<td>3.93</td>
</tr>
<tr>
<td>11. Motivate me to explore clinical topics in more depth</td>
<td>Pre</td>
<td>106</td>
<td>0</td>
<td>6.60</td>
<td>20.75</td>
<td>55.66</td>
<td>16.98</td>
<td>3.83</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>106</td>
<td>2.83</td>
<td>8.49</td>
<td>23.58</td>
<td>40.57</td>
<td>24.53</td>
<td>3.76</td>
</tr>
<tr>
<td>12. Help me achieve the learning outcomes of the course</td>
<td>Pre 106</td>
<td>0</td>
<td>0.95</td>
<td>13.33</td>
<td>72.38</td>
<td>13.33</td>
<td>3.98</td>
<td>0.234</td>
</tr>
<tr>
<td>13. Assist me in getting the best grade I can for the course</td>
<td>Post 106</td>
<td>0.94</td>
<td>2.83</td>
<td>15.09</td>
<td>53.83</td>
<td>28.30</td>
<td>4.05</td>
<td>0.003*</td>
</tr>
<tr>
<td>14. Be a good resource for me to practice the steps in approaching a clinical case</td>
<td>Pre 106</td>
<td>0</td>
<td>0</td>
<td>4.72</td>
<td>65.09</td>
<td>30.19</td>
<td>4.25</td>
<td>0.506</td>
</tr>
<tr>
<td>15. Be a good study tool for my future courses</td>
<td>Post 106</td>
<td>0</td>
<td>2.83</td>
<td>9.43</td>
<td>43.40</td>
<td>44.34</td>
<td>4.29</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>16. Improve my decision-making accuracy</td>
<td>Pre 106</td>
<td>0</td>
<td>7.55</td>
<td>33.02</td>
<td>49.06</td>
<td>10.38</td>
<td>3.62</td>
<td>0.904</td>
</tr>
<tr>
<td>17. Increase my confidence in my abilities to approach a clinical case</td>
<td>Post 106</td>
<td>0</td>
<td>6.60</td>
<td>16.98</td>
<td>43.40</td>
<td>33.02</td>
<td>4.03</td>
<td></td>
</tr>
<tr>
<td>18. Increase my confidence in making clinical decisions</td>
<td>Pre 106</td>
<td>0</td>
<td>4.72</td>
<td>16.04</td>
<td>60.38</td>
<td>18.87</td>
<td>3.93</td>
<td>0.242</td>
</tr>
</tbody>
</table>

Likert-scale item measurements: 1 (SD = Strongly Disagree), 2 (D = Disagree), 3 (N = Neutral), 4 (A = Agree), 5 (SA = Strongly Agree). Mean pre- and post-questionnaire responses of each item were compared using the nonparametric Wilcoxon signed-rank test. Data are expressed as % of the 106 respondents to both questionnaires. *p≤0.05.
Table 3.3: Student’s responses to questions regarding the perceived effectiveness of a CBEL tool in teaching each clinical step in a methodical approach to a clinical case used in a second-year clinical medicine course. Frequency distribution, mean score, and significance of students’ perceptions are reported, pre- and post-CBEL use, using the nonparametric Wilcoxon signed-rank test.

<table>
<thead>
<tr>
<th>Clinical Case Step</th>
<th>N</th>
<th>SD (%)</th>
<th>D (%)</th>
<th>N (%)</th>
<th>A (%)</th>
<th>SA (%)</th>
<th>Mean</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Understand a patient history</td>
<td>Pre</td>
<td>106</td>
<td>0</td>
<td>2.83</td>
<td>14.15</td>
<td>62/26</td>
<td>20.75</td>
<td>4.01</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>106</td>
<td>1.89</td>
<td>3.77</td>
<td>12.26</td>
<td>47.17</td>
<td>34.91</td>
<td>4.09</td>
</tr>
<tr>
<td>2. Understand a physical exam</td>
<td>Pre</td>
<td>106</td>
<td>1.89</td>
<td>11.32</td>
<td>16.04</td>
<td>57.55</td>
<td>13.21</td>
<td>3.69</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>106</td>
<td>3.77</td>
<td>4.72</td>
<td>16.04</td>
<td>45.28</td>
<td>30.19</td>
<td>3.93</td>
</tr>
<tr>
<td>3. Create a problem list</td>
<td>Pre</td>
<td>106</td>
<td>0</td>
<td>0.94</td>
<td>5.66</td>
<td>55.66</td>
<td>37.74</td>
<td>4.30</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>106</td>
<td>0</td>
<td>1.89</td>
<td>4.72</td>
<td>37.74</td>
<td>55.66</td>
<td>4.47</td>
</tr>
<tr>
<td>4. Create a differential diagnosis list</td>
<td>Pre</td>
<td>106</td>
<td>0</td>
<td>0</td>
<td>6.60</td>
<td>61.32</td>
<td>32.08</td>
<td>4.26</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>106</td>
<td>0</td>
<td>3.77</td>
<td>3.77</td>
<td>42.45</td>
<td>50.00</td>
<td>4.39</td>
</tr>
<tr>
<td>5. Decide which diagnostics are most appropriate</td>
<td>Pre</td>
<td>106</td>
<td>0.94</td>
<td>2.83</td>
<td>10.38</td>
<td>58.49</td>
<td>27.36</td>
<td>4.09</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>106</td>
<td>0</td>
<td>2.83</td>
<td>9.43</td>
<td>36.79</td>
<td>50.94</td>
<td>4.36</td>
</tr>
<tr>
<td>6. Develop a treatment plan</td>
<td>Pre</td>
<td>106</td>
<td>0.94</td>
<td>1.89</td>
<td>13.21</td>
<td>59.43</td>
<td>24.53</td>
<td>4.05</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>106</td>
<td>0.94</td>
<td>4.72</td>
<td>8.49</td>
<td>43.40</td>
<td>42.45</td>
<td>4.22</td>
</tr>
<tr>
<td>7. Follow up with a patient's treatment plan</td>
<td>Pre</td>
<td>106</td>
<td>1.89</td>
<td>5.66</td>
<td>22.64</td>
<td>52.83</td>
<td>16.98</td>
<td>3.77</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>106</td>
<td>4.72</td>
<td>3.77</td>
<td>21.70</td>
<td>44.34</td>
<td>25.47</td>
<td>3.82</td>
</tr>
</tbody>
</table>

Likert-scale item measurements: 1 (SD = Strongly Disagree), 2 (D = Disagree), 3 (N = Neutral), 4 (A = Agree), 5 (SA = Strongly Agree). Mean pre- and post-questionnaire responses of each item were compared using the nonparametric Wilcoxon signed-rank test. Data are expressed as % of the 106 respondents to both questionnaires. * p≤0.05.
Table 3.4: Students’ responses to questions regarding the extent in which various CBEL learning outcomes may increase clinical confidence in a second-year clinical medicine course. Frequency distribution, mean score, and significance of students’ perceptions are reported, pre- and post-CBEL use, using the nonparametric Wilcoxon signed-rank test.

<table>
<thead>
<tr>
<th>Clinical Confidence Statements</th>
<th>N</th>
<th>1 (%)</th>
<th>2 (%)</th>
<th>3 (%)</th>
<th>4 (%)</th>
<th>5 (%)</th>
<th>6 (%)</th>
<th>7 (%)</th>
<th>8 (%)</th>
<th>9 (%)</th>
<th>10 (%)</th>
<th>Mean</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Increasing my knowledge retention</td>
<td>Pre 106</td>
<td>1.89</td>
<td>1.89</td>
<td>0.94</td>
<td>2.83</td>
<td>10.38</td>
<td>15.09</td>
<td>19.81</td>
<td>30.19</td>
<td>11.32</td>
<td>5.66</td>
<td>7.01</td>
<td>0.052</td>
</tr>
<tr>
<td></td>
<td>Post 106</td>
<td>3.77</td>
<td>0.94</td>
<td>4.72</td>
<td>3.77</td>
<td>11.32</td>
<td>15.09</td>
<td>23.58</td>
<td>20.75</td>
<td>8.49</td>
<td>7.55</td>
<td>6.65</td>
<td></td>
</tr>
<tr>
<td>2. Applying knowledge to a real case</td>
<td>Pre 106</td>
<td>0</td>
<td>0</td>
<td>0.94</td>
<td>1.89</td>
<td>0.94</td>
<td>1.89</td>
<td>10.38</td>
<td>23.58</td>
<td>33.02</td>
<td>18.87</td>
<td>8.49</td>
<td>7.67</td>
</tr>
<tr>
<td></td>
<td>Post 106</td>
<td>0</td>
<td>0</td>
<td>0.94</td>
<td>2.83</td>
<td>2.83</td>
<td>12.26</td>
<td>22.64</td>
<td>23.58</td>
<td>16.98</td>
<td>16.04</td>
<td>7.67</td>
<td></td>
</tr>
<tr>
<td>3. Navigating through a clinical case</td>
<td>Pre 106</td>
<td>0</td>
<td>0.94</td>
<td>0</td>
<td>0</td>
<td>5.15</td>
<td>6.67</td>
<td>15.24</td>
<td>37.74</td>
<td>18.87</td>
<td>7.55</td>
<td>7.70</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Post 106</td>
<td>0.94</td>
<td>1.89</td>
<td>0.94</td>
<td>0.94</td>
<td>4.72</td>
<td>6.60</td>
<td>19.81</td>
<td>31.13</td>
<td>18.87</td>
<td>14.15</td>
<td>7.74</td>
<td>0.533</td>
</tr>
<tr>
<td>4. Learning the process of a clinical case</td>
<td>Pre 106</td>
<td>0</td>
<td>1.90</td>
<td>0</td>
<td>0</td>
<td>5.71</td>
<td>6.67</td>
<td>15.24</td>
<td>41.90</td>
<td>20.95</td>
<td>7.62</td>
<td>7.79</td>
<td>0.653</td>
</tr>
<tr>
<td></td>
<td>Post 106</td>
<td>0.94</td>
<td>1.89</td>
<td>0</td>
<td>1.89</td>
<td>0.94</td>
<td>11.32</td>
<td>22.64</td>
<td>24.53</td>
<td>20.75</td>
<td>15.09</td>
<td>7.77</td>
<td></td>
</tr>
<tr>
<td>5. Practicing critical thinking and problem solving</td>
<td>Pre 106</td>
<td>1.89</td>
<td>0.94</td>
<td>0</td>
<td>0.94</td>
<td>4.72</td>
<td>10.38</td>
<td>24.53</td>
<td>30.19</td>
<td>17.92</td>
<td>8.49</td>
<td>7.53</td>
<td>0.292</td>
</tr>
<tr>
<td></td>
<td>Post 106</td>
<td>1.89</td>
<td>2.83</td>
<td>1.89</td>
<td>1.89</td>
<td>5.66</td>
<td>8.49</td>
<td>24.53</td>
<td>28.30</td>
<td>12.26</td>
<td>12.26</td>
<td>7.31</td>
<td></td>
</tr>
<tr>
<td>6. Integrating knowledge from other classes</td>
<td>Pre 106</td>
<td>0</td>
<td>0</td>
<td>1.89</td>
<td>3.77</td>
<td>5.66</td>
<td>11.32</td>
<td>23.76</td>
<td>28.30</td>
<td>16.04</td>
<td>5.66</td>
<td>7.36</td>
<td>0.913</td>
</tr>
<tr>
<td></td>
<td>Post 106</td>
<td>1.89</td>
<td>1.89</td>
<td>1.89</td>
<td>0.94</td>
<td>4.72</td>
<td>13.21</td>
<td>25.47</td>
<td>25.47</td>
<td>14.15</td>
<td>10.38</td>
<td>7.31</td>
<td></td>
</tr>
<tr>
<td>7. Validation of knowledge</td>
<td>Pre 106</td>
<td>0.94</td>
<td>1.89</td>
<td>3.77</td>
<td>0.94</td>
<td>3.77</td>
<td>5.66</td>
<td>23.58</td>
<td>30.19</td>
<td>22.64</td>
<td>6.60</td>
<td>7.49</td>
<td>0.514</td>
</tr>
<tr>
<td></td>
<td>Post 106</td>
<td>0.94</td>
<td>0.94</td>
<td>0.94</td>
<td>2.83</td>
<td>10.38</td>
<td>4.72</td>
<td>17.92</td>
<td>25.47</td>
<td>21.70</td>
<td>14.15</td>
<td>7.63</td>
<td></td>
</tr>
<tr>
<td>8. Demonstrating veterinary competencies</td>
<td>Pre 106</td>
<td>3.77</td>
<td>1.89</td>
<td>2.83</td>
<td>0.94</td>
<td>9.43</td>
<td>9.43</td>
<td>25.47</td>
<td>21.70</td>
<td>19.81</td>
<td>4.72</td>
<td>7.01</td>
<td>0.639</td>
</tr>
<tr>
<td></td>
<td>Post 106</td>
<td>3.77</td>
<td>1.89</td>
<td>4.72</td>
<td>2.83</td>
<td>10.38</td>
<td>10.38</td>
<td>22.64</td>
<td>23.58</td>
<td>9.43</td>
<td>10.38</td>
<td>6.83</td>
<td></td>
</tr>
</tbody>
</table>

Scale items were measured from 1 (Not at all) to 10 (Extremely). Mean pre- and post-questionnaire responses of each item were compared using the nonparametric Wilcoxon signed-rank test. Data are expressed as % of the 106 respondents to both questionnaires. * p≤0.05.
Table 3.5: Students’ mean responses to pooled questions in the following scales regarding the use of a CBEL tool in a second-year clinical medicine course: perceived effectiveness of achieving CBEL outcomes; perceived effectiveness of teaching a methodical approach to a clinical case; clinical confidence. Mean score and significance of students’ perceptions are reported, pre- and post-CBEL use, using the nonparametric Wilcoxon signed-rank test.

<table>
<thead>
<tr>
<th>Scale</th>
<th>N</th>
<th>Mean</th>
<th>Mean Diff</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceived Effectiveness – CBEL Outcomes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>105</td>
<td>3.89</td>
<td>+0.08</td>
<td>0.121</td>
</tr>
<tr>
<td>Post</td>
<td>106</td>
<td>3.95</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceived Effectiveness – Case Method</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>106</td>
<td>4.02</td>
<td>+0.160</td>
<td>0.017*</td>
</tr>
<tr>
<td>Post</td>
<td>106</td>
<td>4.18</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Scale items were measured from 1 (Strongly Disagree) to 5 (Strongly Agree).

| Clinical Confidence                   |     |      |           |     |
| Pre                                   | 105 | 7.44 | -0.07     | 0.650 |
| Post                                  | 106 | 7.36 |           |     |

Scale items were measured from 1 (Not at all) to 10 (Extremely).

Mean pre- and post-questionnaire responses of each scale were compared using the nonparametric Wilcoxon signed-rank test. Data are expressed as % of the 106 respondents to both questionnaires. * p≤0.05.
Table 3.6: Spearman correlation of perceived learning preferences from the pre-use questionnaire and measured outcomes from the post-use questionnaire.

<table>
<thead>
<tr>
<th>Learning Preference</th>
<th>Perceived Effectiveness – CBEL Outcomes</th>
<th>Perceived Effectiveness – Case Method</th>
<th>Clinical Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Spearman’s correlation coefficient, ( n = 106 ) ( \text{prob} &gt;</td>
<td>r</td>
<td>) under H0: ( \rho = 0 )</td>
</tr>
<tr>
<td>Read/Memorize</td>
<td>Corr. Coefficient</td>
<td>0.094</td>
<td>0.021</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>0.321</td>
<td>0.830</td>
</tr>
<tr>
<td>Practice &amp; Apply</td>
<td>Corr. Coefficient</td>
<td>0.190</td>
<td>0.288</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>0.051</td>
<td>0.003*</td>
</tr>
<tr>
<td>Visual</td>
<td>Corr. Coefficient</td>
<td>0.073</td>
<td>0.140</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>0.460</td>
<td>0.151</td>
</tr>
<tr>
<td>Group</td>
<td>Corr. Coefficient</td>
<td>0.108</td>
<td>0.089</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>0.271</td>
<td>0.264</td>
</tr>
<tr>
<td>Hands On</td>
<td>Corr. Coefficient</td>
<td>0.297</td>
<td>0.233</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>0.002*</td>
<td>0.016*</td>
</tr>
</tbody>
</table>

* \( p \leq 0.05 \).
CHAPTER FOUR

General Discussion, Limitations, Future Directions, and Conclusion
General Discussion

The overall goal of this thesis was to gain an insight into veterinary students’ perceptions of the use and effectiveness of a purpose-built CBEL tool in a second-year clinical medicine course at the OVC. Specifically, we aimed to explore changes in veterinary students’ perceived knowledge and skills, learning behaviour, as well as satisfaction and attitudes when using a CBEL tool.

Chapter 2

In Chapter 2, we investigated students’ views around the utility and usability of a CBEL tool, including recommendations for future design, implementation and use. Students reported positive experiences working with their peers when asked about the social environment associated with using a CBEL tool, they cited that they were comfortable working with their peers without the risk of social repercussions. This is consistent with previous CBL (Khosa et al., 2010) and e-learning (Ellaway & Masters, 2008) research. Considering social environment and student interaction when delivering CBEL is important as negative social experiences may discourage students from using CBEL, thereby hampering the potential for the tool to facilitate the achievement of learning outcomes. Additionally, students in our study explained that a supervising instructor does not have to be actively involved during CBEL use, however, should still be present and available to guide discussion and answer questions. Previous studies have reported that an instructor is essential to the learning experience and could not be replaced by an e-learning tool (Seabra et al., 2004; Short & McConnell, 1997). Students in our study further elaborated that they valued the inclusion of feedback at each step of the clinical cases within the
CBEL tool itself, which was consistent with Creevy et al. (2017). Our findings in conjunction with the previous research noted above suggest that a blended learning environment where lectures are supported with in-person facilitated case-based e-learning activity may be the optimal method of delivering CBEL.

We also assessed students’ perceptions of satisfaction and enjoyment prior to and after the use of a CBEL tool. Perceived usefulness and satisfaction have previously been shown to contribute to learners’ behavioural intention to use an e-learning system (Liaw, 2008). Those who enjoy the manner in which material is being taught also tend to better achieve learning outcomes (Patterson et al., 2007). Students in our study emphasized that the design and utility of the online cases, particularly their authenticity, were instrumental in their perspectives and acceptance of the CBEL tool. Previous studies in human medical education have similarly reported the benefits of increased media use and higher fidelity simulations in e-learning environments, as they provide more context to understanding complex principles and tasks and have been shown to better promote a transfer of clinical abilities to real patients (Issenberg et al., 2005; Huwendiek et al., 2009; Jin & Bridges, 2014). Students in the present study explained that a more realistic learning experience through authentic cases may translate into increased confidence and better preparedness in real life practice. Patterson (2006) previously found similar results that demonstrated an increase in confidence resulted in improved clinical reasoning skills in a CBL capacity. Logistic considerations such as the inclusion of costs for clinical tests and procedures were also deemed imperative for the students in our study. Aspects such as cost considerations were not originally considered important when designing the online cases because there was concern that this may add an extra layer of complexity to the cases,
potentially distracting students from the original purpose of knowledge application and learning a methodical approach to a clinical case. This demonstrates the level of detail and precision that students are looking for when using a CBEL tool and suggests that logistic factors may hold as much value as visual aspects of case design. We would suggest improving the realism of a CBEL tool to mimic a live animal case which may increase students’ acceptance and satisfaction in use. Using real or highly representative pictures, videos and sound would all help to increase the fidelity of cases and may contribute to an increased understanding in knowledge application and facilitating navigation through case material. Including logistic considerations to better portray the decision-making process that a practicing veterinarian experiences, would also provide a complete view to each case and help students understand all considerations applicable to approaching and navigating a clinical case.

Furthermore, students emphasized that they had to feel engaged through solid technical design and utility. Supporting conclusions can be found by Shee and Wang (2008) as well as Welsh et al. (2003) who explain that students highly value the user interface of web-based e-learning. And as long as technical difficulties are not overwhelming, participants who use technologically-driven learning methods have positive attitudes, are satisfied with their learning experience, and are willing to use it again. Accessibility, interactivity, and practicality of the online cases were also positively rated by our students and have previously been cited as benefits of CBEL (Welsh et al., 2003). Students explained these factors gave them the ability to learn at their own time and pace as well as created the opportunity to practice and apply knowledge and skills learned in lectures. Utility perspectives and student acceptance of CBEL should be
considered in future design and implementation of a CBEL tool, especially for veterinary students.

The results from this chapter in conjunction with previous research in the domain of educational methods highlights technical design and utility as imperative considerations in designing and delivering effective e-learning modalities. Although Articulate Storyline 2® was the e-learning tool chosen to design the online cases that were evaluated in this project, there are many newer and more robust e-learning tools available to design and deliver CBEL. Tools such as Adobe Captivate® and Elucidat® are highly cited and powerful e-learning authoring software that perform similar but upgraded functions compared to Articulate Storyline 2®. These tools would be recommended over Articulate Storyline 2® for educational institutions that have more financial flexibility and are not as constrained in resource availability. For the majority of educational institutions, resource availability and financial constraints often pose challenges. There are many free or low-cost tools such as Easygenerator® that tailor to those who do not have an e-learning background, are housed on the Internet, and can be uploaded to a learning management system (LMS) that is already in use. These considerations may be a solution for further scaling the use of CBEL not only in the clinical medicine course hosting this study, but also in other capacities at the OVC.

The LMS used to house Articulate Storyline 2® in this study, CourseLink® allowed only for limited information to be automatically collected when tracking and evaluating students’ activity in using the CBEL tool. This is likely due to the fact that the online cases are externally created and simply housed in the LMS. Additional products are available that bridge this gap, such as Articulate 360® and Blackboard Analytics for Learn™. These allow the creation and
housing of CBEL including tracking of students’ use of each online case. The benefit of these products is the improved ability to monitor students’ CBEL-use at a more microscopic level, providing insight into each decision point that students encounter in each case they attempt. As a result, instructors are provided with the ability to pinpoint exactly where students may be having trouble in grasping concepts in order to provide more targeted and efficient guidance. As a result, time and resources are not wasted for non-specific or unhelpful teaching interventions and may improve pre-specified skills and outcomes that the CBEL tool aims to improve. In turn, this may translate to better preparedness and therefore, potential for better patient outcomes when practicing with real cases. The cost of these products may be a deterrent as previously mentioned.

Chapter 3

In Chapter 3, we evaluated students’ perceived effectiveness of a CBEL tool, and measured students’ self-confidence in application and use of clinical knowledge and skills when using a CBEL tool. We also explored the relationship between perceived learning preferences of veterinary students and the use of CBEL. Students perceived the CBEL tool as highly effective in both achieving CBEL outcomes, as well as teaching a methodical approach to a clinical case. Specifically, students reported that the online cases prioritized understanding over memorization by challenging their problem solving and critical thinking abilities. In turn, this helped provide context to clinical knowledge learned in lectures as well as insight into how and when to apply this knowledge in a clinical case. Similarly, previous research has concluded that the ability to practice clinical decision making through a CBEL tool may facilitate and improve students’ problem solving and decision making competencies when transitioning to a real clinical
environment (Creevy et al., 2017). Additionally, CBEL outcomes were shown to increase clinical confidence in this study after CBEL use. Although it seems promising that a CBEL tool may increase clinical confidence, an increase in confidence does not necessarily translate to an increase in competence, with some evidence demonstrating that confidence poorly predicts future performance in assessments using clinical scenarios (Morgan & Cleave-Hogg, 2002).

Additionally, exploration of students’ preferred approach to learning in this study revealed that hands on learners and those who prefer to learn by practicing and applying knowledge were more likely to show positive perceptions of a CBEL tool. Interestingly, significant correlations were not seen in any outcome with visual learners, those who prefer to read and memorize, nor those who prefer to work in groups. This is surprising as CBEL is tailored to appeal to collaborative and visual learners. As noted in Chapter 2 as well as in previous studies conducted in human medical education (e.g. Issenberg et al., 2005; Huwendiek et al., 2009; Jin & Bridges, 2014), students highly value the realism of online cases. The low-fidelity nature of the visual elements of our cases may account for the poor correlation observed with visual learners. Our results suggest that learning styles may play a role in CBEL use and effectiveness, although we did not employ a validated learning style inventory which may provide more evidence that is comparable to the existing literature.

The Kirkpatrick Model (Kirkpatrick & Kirkpatrick K J, 2006) is often used to review the medical education literature to provide a detailed summary of current research results, as well as aggregated conclusions and recommendations about a teaching modality. In this thesis, we only evaluated the first level of The Kirkpatrick Model, Reaction, by collecting students’ perspectives on the use of a CBEL tool in the clinical medicine course. Although a valid starting point to
begin exploring new educational tools, evaluating the ability of a CBEL tool to achieve learning outcomes would provide more information about its value. Some of the major competencies that our CBEL tool was designed to teach are application of clinical knowledge, decision making and clinical reasoning, as well as navigating a clinical case. The results of this thesis indicate that students believe a CBEL tool helped them become more confident in doing so, however as already discussed confidence does not necessarily translate to competence (Morgan & Cleave-Hogg, 2002). The next three levels of The Kirkpatrick model - Learning, Behaviour, Results, should be evaluated to further validate this claim. Learning typically evaluates knowledge retention post-intervention (Kirkpatrick & Kirkpatrick K J, 2006). Students using a CBEL tool should be tested on clinical content and compared to students using a differing teaching modality such as lectures or CBL. In order to determine if CBEL increases knowledge retention long-term, the same students should be re-tested on the same clinical concepts at least once in the future and compared again. Increased knowledge retention long-term may indicate that students are understanding the CBEL tool content as opposed to memorizing. Behaviour is typically evaluated by assessing changes in practice (Kirkpatrick & Kirkpatrick K J, 2006). As previously mentioned, the CBEL tool used in this study was designed to teach students how to apply clinical knowledge, improve decision making abilities, and navigate a clinical case. Students should be assessed on these abilities prior to using a CBEL tool to determine a baseline and assessed again after using the CBEL tool to determine if they improve. Finally, Results is typically measured by determining the return on investment after implementing an intervention (Kirkpatrick & Kirkpatrick K J, 2006). Traditionally, this might be achieved by assessing patient outcomes or client satisfaction after implementation of a CBEL tool, making this level perhaps a little less
applicable to assess with second-year DVM students. However, creating a situation where an evaluator assumes the role of a client who has come into the clinic and assesses students’ knowledge based on a mock patient encounter may be one way of assessing the final Results level. Using The Kirkpatrick Model provides a robust evaluation of the effectiveness of a CBEL tool. Positive results in each level may indicate that a CBEL is effective at teaching students how to apply clinical knowledge, improve decision making and clinical reasoning competencies, as well as navigate a clinical case. In turn, this may help in the validation of CBEL as an effective tool to bridge the gap between lecture and live animal practice.

In our study, the cases used in the CBEL tool were limited to small animal medicine. The positive results in this study warrant exploration of CBEL in student courses focused on other groups of animals such as food production and equine medicine. Similarly, expanding the use of CBEL to other subjects such as veterinary surgery may have interesting implications. In surgical training specifically, cases could be designed to react to or provide feedback on the choices a student makes, yielding different outcomes and consequences after each step of a procedure. As a result, students would see the outcome of each decision that is made, promoting understanding over memorization of why each step is completed, thereby fostering deeper learning. This would also reinforce the development of decision making and clinical reasoning skills and provide students with a safe space to learn the steps in a surgical procedure.

Several e-learning benefits have been associated with CBEL such as interactivity, accessibility, and the immersive nature of online cases (Welsh et al. 2003). Previous medical education research indicates that these benefits may allow students to learn effectively, be more confident, and perform better when compared to traditional learning modalities (Taradi et al.}
2005; Ruiz et al. 2006; Howlett et al. 2009; Kandasamy & Fung, 2009; Kolb et al. 2009; Rowe et al. 2012; Gaupp et al. 2016; Creevy et al. 2018; Kleinsorgen et al. 2018). Although CBEL use has been widely accepted in human medical education and is promising in veterinary medicine, new and more technologically-centered learning modalities have recently been introduced and shown to be effective. Virtual reality (VR) has gained popularity in human medical education and has shown to be effective in learning anatomy (Nicholson et al. 2006), surgery simulation (Larsen et al. 2009), and in CBL (Coulter et al. 2007). Specifically, Coulter et al. (2007) found that students who practiced approaching a clinical case in a highly-immersive VR environment showed better future clinical knowledge and understanding when compared to students who practiced in a minimally-immersive environment. Game-based learning (GBL) has also shown promise in human medical education. GBL, specifically in an e-learning context, is the use of educational games delivered through a computer or the Internet to enhance the learning experience (Rondon et al. 2012). Common characteristics of GBL include problem-solving and feedback components (Rondon et al. 2012). Students are presented with various possibilities in different scenarios and are required to consider elaborate solutions in order to determine predetermined goals in an enjoyable manner (Rondon et al. 2012). Rondon et al. (2012) reported students who used GBL methods achieved higher post-test scores in an anatomy course when compared to those who learned through traditional lectures. Conflicting results were found by Telner et al. (2010) in a study comparing effectiveness of GBL and CBL at a continuing medical education conference. Knowledge test results immediately after the event and three months later showed no difference between groups, although the GBL group reported higher levels of satisfaction with their learning modality. GBL is considered to potentially facilitate more group
interaction and discussion in addition to increasing student motivation to learn (Telner et al. 2010). GBL and VR have been promising in human medical education and should be further explored in veterinary medical education to determine whether they are more effective at delivering learning outcomes when compared to CBEL and other traditional teaching methods.

**Limitations**

This study measured self-reported perceptions towards CBEL use in a clinical medicine course with students who are still early in their veterinary medicine program. These perceptions may differ in cohorts that are more experienced in veterinary medicine and are further along in their program. Additionally, student perceptions may not truly represent behaviour change, or improvements in CBEL outcomes such as knowledge retention and critical thinking ability. These results should be interpreted as preliminary findings that provide insight into student experience with CBEL. Furthermore, the lack of a comparison group limits the ability to determine if the reported results differ from other learning modalities such as CBEL-use outside of a blended learning environment, traditional didactic lectures, or traditional CBL. Only short-term effects can be detected in a within-subject design with pre- and post-use evaluation. Repeated measures and longer follow-up timeframes may be necessary to evaluate long-term perceptions. Given that the participants in this study were a convenience sample from the OVC, generalizability of results may be limited. There is a possibility of bias as a result of students having positive perceptions of the clinical medicine course or from student excitement in using a new learning modality in the course. This may result in inflated positive results, particularly in the pre-use questionnaire. Finally, the voluntary nature of the research and the chance that those
who were more motivated in the course may have chosen to participate may create a risk of selection bias. The high response rate in the study may negate this.

**Future Directions**

The research presented in Chapters 2 and 3 in conjunction with previous literature, along with the points raised in the above discussion, warrants consideration of further research in CBEL.

The relationship between CBEL and outcomes such as knowledge retention, learning behaviour, and clinical decision making should be explored. A longitudinal study following student cohorts exposed to CBEL across multiple centres may provide a more widely representative insight into the long-term effects of this learning modality. Comparisons between early and experienced DVM students may describe changes in the needs of students as they progress through their degree program. Comparisons across courses as well as across veterinary specialties may provide insight into the most appropriate uses of CBEL.

CBEL should be compared with previously studied learning modalities such as lectures and CBL as well as newer learning modalities such as VR and GBL to provide insight into their compared effectiveness. This would also provide further validation when deciding on the implementation of educational tools in veterinary medical education conditional upon available resources.

The association between confidence and competence after CBEL-use should be explored to determine the ability for CBEL to help achieve learning outcomes in veterinary medical
education. The Kirkpatrick Model (Kirkpatrick & Kirkpatrick K J, 2006) can be used to help design multiple studies that would provide an extensive evaluation of CBEL competencies and can help demonstrate a change in students’ behaviour along with evidence of improvement in clinical competencies.

Finally, further research should be conducted in veterinary medical education on the impact of learning styles in CBEL delivery. Validated learning style inventories such as the Myers-Briggs type model (Myers et al., 1998), Kolb’s learning style model (Kolb, 1985), and the Felder-Silverman learning style model (Felder, 1993) could be utilized in order to validate the results reported in this study. Additionally, exploring the social dynamics of the use of a CBEL tool in conjunction with student learning styles may help determine an optimal method of implementation in veterinary medical education and how to best target various types of learners.

Conclusion

The design, implementation, and use of CBEL has been identified as a promising way to address challenges with physical resources, limitations of space, and the availability of real-life teaching cases in educational settings. CBEL is generally accepted and valued in healthcare education as an efficient, effective and sustainable learning mode, but little attention has been given to CBEL in the veterinary medical education literature.

Our results support the notion that CBEL is a viable option as a learning modality in veterinary medical education. Students demonstrated high satisfaction and enjoyment with a CBEL tool used in a clinical medicine course. Students also perceived the CBEL tool as highly effective in both achieving CBEL outcomes as well as teaching a methodical approach to a
clinical case. Various CBEL learning outcomes were also shown to increase clinical confidence after CBEL use. These findings support the notion that CBEL may be effective at creating a bridge between lecture and live animal practice, allowing students to safely explore complex relationships between clinical concepts in a controlled setting, and understand the essential steps and decisions required during live animal practice. In addition, hands on learners and those who prefer to learn by practicing and applying knowledge were more likely to show positive perceptions of the CBEL tool, suggesting that learning styles may play a role CBEL use and effectiveness.

The results of this study provide a platform for further exploration of the use and effectiveness of this learning modality in veterinary medical education as well as future considerations when implementing CBEL in other capacities.
REFERENCES


APPENDICES
Appendix A

Participant Consent Form – Case-Based E-Learning Focus Groups
E-Learning Evaluation Focus Groups
REB17-01-009
Student Consent

You are invited to participate in a research study conducted by Dr. Deep Khosa (Primary Investigator), Dr. Alice Defarges (Faculty Co-Investigator), and Michael Sawras (Master’s student).

PURPOSE OF THE STUDY

The main purpose of this study is to gather feedback and information regarding how you feel about the e-learning tool Articulate Storyline 2 used in Clinical Medicine II or other educational settings and how it affects your learning.

PROCEDURES

Your participation in this study is completely voluntary. If you decide to participate in this study, you will be required to attend a focus group to discuss the usability and sustainability of Articulate Storyline 2 and how it has affected your learning in an educational setting. Focus groups will be composed of approximately 5-10 students with feedback and discussion expected from those participating. The entire discussion will be recorded on an audio recorder and transcribed by a professional transcriber. Focus Groups will run for approximately 1.5 hrs. Your feedback and comments will not impact your grade in Clinical Medicine II or any other class you are enrolled in. The focus group is a method of evaluating this teaching method and assessing its impact in the OVC and Clinical Medicine II curriculum.

POTENTIAL RISKS AND DISCOMFORTS

We do not foresee any major risks or discomforts; however, we are aware that it may be initially uncomfortable to participate in the discussion and voice your opinion in front of your peers. Please be assured that respect will be maintained and the session will be facilitated, providing a supportive environment at all times.

POTENTIAL BENEFITS TO PARTICIPANTS AND/OR TO SOCIETY

We expect that the feedback you provide us through this project will greatly benefit future learning of veterinary students.

PAYMENT/INCENTIVES

Although there is no payment for participating in this study, you will be compensated with a free meal and $10 Tim Horton’s gift card following the completion of the session. Should you withdraw from the study before the completion of the session, the gift card will be made available to you prior to leaving.

CONFIDENTIALITY

We will try to keep your responses confidential; however, please note that by voicing your opinions your views will be made public to the other participants in the focus group. Participants will be urged to respect each other’s privacy by not discussing who was present or what was said, but the research team cannot control this. The information you provide will only be accessible to the primary investigator, student investigator, and transcriber. Dr. Defarges will be given access to de-identified transcripts after all grades have been submitted. All data will be stored in a lockable space in Michael Sawras’ home office that is secured, and there will not be any identifying information attached to data that may be published. Once data is collected and analyzed, your names will be removed as soon as possible. Your names will not be used for any other purpose.

PARTICIPATION AND WITHDRAWAL

If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. You may also refuse
to answer any questions you don’t want to answer and still remain in the study. Due to the nature of the study, any contributions in the focus groups prior to withdrawal from the study cannot be removed, should you choose to remove yourself from the study. The investigator may withdraw you from this research if circumstances arise that warrant doing so.

WHO TO CONTACT?

If you have any questions or concerns about the research, please feel free to contact Dr. Khosa (Primary Investigator) on 519 824 4120 ext. 54470 or email dkhosa@uoguelph.ca

RIGHTS OF RESEARCH PARTICIPANTS

If you have questions regarding your rights and welfare as a research participant in this study (REB#17-01-009), please contact: Director, Research Ethics; University of Guelph; reb@uoguelph.ca; (519) 824-4120 (ext. 56606). Please note that confidentiality cannot be guaranteed while data are in transit over the internet. You do not waive any legal rights by agreeing to take part in this study. This project has been reviewed by the Research Ethics Board for compliance with federal guidelines for research involving human participants.

SIGNATURE OF RESEARCH PARTICIPANT/LEGAL REPRESENTATIVE

I have read the information provided for the study as described herein. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.

Name of Student (please print)  Email address (if you want feedback on results)

Signature of Student  Date
Appendix B

Case-Based E-Learning Focus Group Question Guide
STUDENT FOCUS GROUP
AN ASSESSMENT OF E-LEARNING IN VETERINARY STUDIES

(Turn on recorders)

Introduction (5 minutes, begin at xx)

☐ Hello and welcome

☐ Thank for taking the time to join me today for this discussion. We are very interested about your thoughts and experiences regarding the use of the e-learning tool Articulate Storyline 2 in your veterinary or other classes.

☐ My name is Michael Sawras and I will be the moderator for today’s discussion.

☐ During our discussion today, I hope to get your thoughts on the use of AS2 in a teaching setting, how this may differ from traditional settings, your comments and feedback on its usability, your satisfaction with the tool and any changes you might make in terms of its use.

☐ I have invited you here today because you have all recently used the e-learning tool in one or more of your veterinary or other classes.

☐ The information collected here today will be taken into account to improve students’ learning experiences at OVC. We may also choose to write up some of the findings from this process for publication.

☐ As you have probably already noticed there are recorders on the table to record our conversation. These recorders are here to capture everything that is said. Myself and a person employed to transcribe the recordings are the only two people who will listen to the recordings. To protect your confidentiality, your names will not be attached to any part of the transcriptions so please feel free to speak freely. Can I request that you please speak up when you are talking so that your valuable comments are captured on the recording.

☐ As you may have also noticed, aside from your fellow students and myself, there is no one else here from the OVC. I am not involved in directly assessing you in any part of your DVM course so there is no conflict of interest in me being present here today. I can assure you that I will hold everything that is said in the room today in the strictest of confidence.

☐ While a focus group methodology cannot assure complete confidentiality, I ask that you do not repeat anything that is said here to others outside of the group.
This is because I want everyone here to feel safe and comfortable about sharing their thoughts and making comments.

☐ My role here today is to ask questions, listen, keep the conversation moving, and be mindful of the time.

☐ I would like to hear from all you but I respect that everyone will participate in different ways. Some people are more talkative, while others are quieter. I will try to ensure that everyone has a chance to speak today, should they choose to contribute. If at any point I have to interrupt you speaking, it will only be because we are running out of time, it is most definitely not because I am not interested in what you have to say.

☐ To help with this process, I am going to ask that only one person speak at any given time. It is okay to disagree with each other because there are no right or wrong answers here.

☐ Please be aware that you have the option to withdraw from this study at any time. If you need to leave today for any reason please do this quietly.

☐ We have 1.5 hours today and there are a number of topics to discuss. Once we are finished today, we will be having lunch/dinner.

☐ So that we are not interrupted while we chat, can I please ask that you turn off any cell phones or electronic devices for the duration of our discussion today? Thank you.

☐ If there are any questions I ask today that are not clear or do not make sense then please ask me to clarify them for you.

☐ Are there any questions? Okay, let’s start.

**Icebreaker** (5 minutes, begin at xx)

☐ So let’s start by going around the table and introducing ourselves. Tell us your name, your favourite place to holiday in the world if money was no object, and your favourite thing to do when you have some spare time.

☐ I will start...

**Participants’ guided discussion of the usability of Articulate Storyline 2** (25 minutes, begin at xx)
As I mentioned, you have all recently taken a class where Articulate Storyline 2 has been used to supplement your learning. I am interested in any comments or suggestions you may have that pertain to its usability, its place in the curriculum, as well as how this tool has affected your learning. This study is being done to evaluate the effectiveness and sustainability of AS2 in the OVC curriculum, overall to determine whether your learning is bettered through its use.

Let’s begin by discussing your experience with Articulate Storyline 2 in terms of its usability. I would like you to take a minute and think about the time you spent using the tool. In terms of the usability, what are some aspects about it that you enjoyed? This can refer to its support, technical layout, or any other aspects of the tool/program itself.

(Go around the room for responses if there is no spontaneous response from anyone to begin the discussion. MS to invite responses from people who did not respond)

Probes:
Could you elaborate on your comment?
Tell me more about why you enjoyed this?
What specifically did this help you with?
If applicable, how is this different than other experiences you have had?

Alternatively, what are some aspects of the eLearning tool you might change in order to better suit your needs?

(Go around the room for responses if there is no spontaneous response from anyone to begin the discussion. MS to invite responses from people who did not respond)

Probes:
Could you elaborate on this?
What would you have done differently if you could change this?
Have you had other experiences that have done a better job in this area?
How do you believe this may have affected your learning?
Is this something you might like completely removed?

Participants’ guided discussion of their satisfaction with Articulate Storyline 2 (10 minutes, begin at xx)

Thinking back to your standard classroom studies, lecture based studies or experiences in the clinic, tell me what experiences were provided by AS2 that you would not have received in any of the other settings?
(Go around the room for responses if there is no spontaneous response from anyone to begin the discussion. MS to invite responses from people who did not respond)

Probes:
Could you elaborate on that?
Was there any negative/positive (opposite) aspect of the tool you haven’t mentioned?
Overall, would you say you are satisfied with the use of the tool?

Participants’ guided discussion of Articulate Storyline 2 in relation to their learning (25 minutes, begin at xx)

Think back to the course you used the eLearning tool in. In what ways did the eLearning tool help you in your content learning during this course?

(Go around the room for responses if there is no spontaneous response from anyone to begin the discussion. MS to invite responses from people who did not respond)

Probe:
Did AS2 help you understand a concept that you perhaps had not understood previously?
Did you feel the knowledge you gained stayed with you for longer than usual?
Did you participate in this learning with others and if so, was this beneficial in an eLearning setting?
Was there any difference in your use of the tool at home versus in lab/at school?

Everyone learns differently. Prior to using the tool, think about how you felt you learned best. After using the eLearning tool, have you seen a change your learning style or behaviour?

(Go around the room for responses if there is no spontaneous response from anyone to begin the discussion. MS to invite responses from people who did not respond)

Probe:
If yes/no, could you elaborate why?
Does this change only happen when using the tool or has it changed how you learn entirely?
Does the tool complement your learning style or hinder it? Elaborate.

Think back to your performance after using the tool in your learning. Did the eLearning tool increase your confidence in your clinical or educational abilities? How so?

(Go around the room for responses if there is no spontaneous response from anyone to begin the discussion. MS to invite responses from people who did not respond)
Probe:
Do you believe you would have developed these abilities regardless?
How does this relate to the tool specifically?

Overall assessment of Articulate Storyline 2 and advice from participants (10 minutes, begin at xx)

If we were to develop a brand new learning curriculum for students at OVC to maximize their learning experience with AS2, what advice would you give us?

(Go around the room for responses if there is no spontaneous response from anyone to begin the discussion. MS to invite responses from people who did not respond)

Probe:
Is the use of AS2 something you would recommend for other students in other classes?
Thinking back to your traditional teaching experiences, in what ways was the eLearning tool similar to your experience in class/other labs?
Similarly, in what ways was the eLearning tool different to your experience in class/other labs?

Summary (5 minutes, begin at xx)

We have covered all the topics for discussion today so I will summarize what we have discussed and would like you to let me know if there is anything I have left out.

We began with talking about the usability of Articulate Storyline 2. Your responses included....

We then went on to discuss the satisfaction you had with the tool and how AS2 may have been different than your traditional learning. Your responses to this included...

Next we discussed how AS2 affected your learning in class as well as your learning style in general. Your comments to this included...

Finally, we talked about how you would use AS2 in a teaching setting if you were to design a curriculum. Your responses to this included...

Is that a fair summary of what we discussed today?
Is there anything else you would like to add to this summary, have I missed anything?

Participants to complete a short demographics questionnaire (1 minute, begin at xx)

(Hand out demographic questionnaire)
The very final thing for you to do today is to fill in this questionnaire about yourselves. It should only take you a minute to complete. The information you provide on this questionnaire is important to us to help keep track of who took part in this discussion. We do not need your name on these as all responses are anonymous and will be kept confidential.

**Conclusion** (1 minute)

Thank you very much for coming today to join in this discussion. This discussion is going to be valuable information for us to use to improve your learning at OVC.

Please help yourselves to some food and beverages.
Appendix C

Participant Demographics Form – Case-Based E-Learning Focus Groups
ONTARIO VETERINARY COLLEGE  
Department of Population Medicine  

Participant Information – Students  
REB17-01-009  

Please complete all the information on this form. All responses will be kept confidential.

1. I am _______ years old  

2. I am: Female_______ Male_______ Other_______  

3. When I graduate I plan to practice in:  
   _____ Small Animal only   _____ Food Animal only  
   _____ Mixed Animal       _____ Equine Only  
   _____ Undecided          _____ Other (Please Specify) _______  

4. My reason(s) for participating in this focus group discussion was/were:  
   ___________________________________________________________  
   ___________________________________________________________  
   ___________________________________________________________  

5. Please feel free to share any other comments regarding your experience today:  
   ___________________________________________________________  
   ___________________________________________________________  
   ___________________________________________________________  
   ___________________________________________________________  
   ___________________________________________________________  
   ___________________________________________________________  
   ___________________________________________________________  
   ___________________________________________________________
Appendix D

Participant Consent Form – Case-Based E-Learning Online Questionnaires
Participant Consent Section – Qualtrics Questionnaire

ONTARIO VETERINARY COLLEGE
Department of Population Medicine

Case-Based E-Learning Evaluation Questionnaire
REB17-01-009

You are invited to participate in a research study investigating the effectiveness of case-based e-learning in veterinary education. This study is being conducted by Dr. Deep Khosa (Primary Investigator), Dr. Alice Defarges (Faculty Co-Investigator), and Michael Sawras (Master’s student) at the Ontario Veterinary College, University of Guelph and is funded by the Learning Enhancement Fund.

PURPOSE OF THE STUDY

The main purpose of this study is to gather feedback and evaluate the effectiveness of the e-learning tool Articulate Storyline 2 used in your course and how it affects your learning.

PROCEDURES

This survey is one of two surveys you will be asked to complete if consenting to participate in this research study. One will be given prior to the use of the case-based e-learning tool in Clinical Medicine II, and the second will be given post-use. The surveys will include a series of multiple choice or scale questions. Topics will include: attitudes and reaction, learning, behaviour changes, and results, all prior to and after the use of the case-based e-learning tool. The time to complete this survey is estimated to be 10-15 minutes. Your feedback and comments will not impact your grade in Clinical Medicine II or any other class you are enrolled in.

POTENTIAL RISKS AND DISCOMFORTS

We do not foresee any major risks or discomforts; however, we are aware that you may be hesitant to participate if you think this impacts your grade in any way. Please be assured that your name will not be tied to any of the questionnaires or responses you provide, other than to compare pre- and post-results, and therefore has no impact what so ever on your grade.

POTENTIAL BENEFITS TO PARTICIPANTS AND/OR TO SOCIETY

This questionnaire is a method of evaluating this teaching method and assessing its impact in your course. We expect that the feedback you provide us through this project will greatly benefit future learning of veterinary students.

PAYMENT/INCENTIVES

Participating in this study gives you the opportunity to go into the draw for various prizes. Each draw will contain two $100 Amazon gift cards, four $50 Best Buy gift cards, and four $25 Starbucks gift cards. You will have the opportunity to enter each draw after completing one of the questionnaires. Should you only complete one questionnaire, you will only be entered in to one draw.

Please note, if you choose to go into the draw for the prizes, the prize draw part of the questionnaire will ask you for identifying information, including your name and contact information. For auditing purposes, the contact information of the prize winners will be recorded. All contact information will remain confidential and deleted once the prize draw is completed.

CONFIDENTIALITY

Your responses will be kept confidential. Your surname will be recorded in both questionnaires simply to compare the results from both submissions. Your name will be removed from each questionnaire once submitted and assigned a de-
identified code. The information you provide will only be accessible to the primary investigator and student investigator. All data will be stored in a lockable space in Michael Sawas’ home office that is secured, and there will not be any identifying information attached to data that may be published. Your names will not be used for any other purpose.

**PARTICIPATION AND WITHDRAWAL**

Due to the anonymity of responses, participants cannot withdraw responses, however they are free to stop participating at any time by simply exiting the questionnaire, without any consequences. Once data analysis has begun, participants will no longer be eligible to remove their data. The investigator may withdraw you from this research if circumstances arise that warrant doing so.

**WHO TO CONTACT?**

If you have any questions or concerns about the research, please feel free to contact Michael Sawas (Master’s Student) at msawras@uoguelph.ca or Dr. Deep Khosa (Primary Investigator) on 519 824 4120 ext. 54470 or email dkhosa@uoguelph.ca.

**RIGHTS OF RESEARCH PARTICIPANTS**

If you have questions regarding your rights and welfare as a research participant in this study (REB#17-01-009), please contact: Director, Research Ethics; University of Guelph; reb@uoguelph.ca; (519) 824-4120 (ext. 56606). Please note that confidentiality cannot be guaranteed while data are in transit over the internet. You do not waive any legal rights by agreeing to take part in this study. This project has been reviewed by the Research Ethics Board for compliance with federal guidelines for research involving human participants.

Do you consent to participate in this survey?

_____ I agree

_____ I disagree

If I disagree is Selected, Then Skip To End of Survey
Appendix E

Pre- Case-Based E-Learning Use Online Questionnaire
**Students' Pre Case-Based E-Learning Questionnaire**

Thank you for agreeing to participate in this important survey. We are interested in learning more about your experiences in using a case-based e-learning tool (Articulate Storyline) in your course. Your responses to this survey will provide us with information to help with your learning experience in this course, and help to inform the veterinary literature on this important subject. Thinking about your experiences with case-based e-learning at this moment in time, please answer the following questions. Your responses here will NOT have any impact on your marks for this course.

This section simply asks a few **Background** questions.

<table>
<thead>
<tr>
<th>What is your understanding of e-learning? (Please select all that apply)</th>
<th>Please select all that apply</th>
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<tbody>
<tr>
<td>It involves:</td>
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<tr>
<td>□ Using an online platform (e.g. CourseLink, Blackboard, etc.) to assist with lecture material distribution, tracking grades, etc.</td>
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<tr>
<td>□ Taking an online course</td>
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<tr>
<td>□ Learning using a computer</td>
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<tr>
<td>□ Learning using a tablet, smartphone, etc.</td>
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<tr>
<td>□ Learning from videos or audio recordings</td>
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<tr>
<td>□ Any learning delivered through the Internet</td>
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<tr>
<td>□ Working through online modules</td>
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<tr>
<td>□ Other (please specify)</td>
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</tbody>
</table>

Please rate your level of experience for the following questions
Scale: 1-5 (1 = No Experience, 2 = Somewhat Experienced, 3 = Moderately Experienced, 4 = Very experienced, 5 = Extremely Experienced)

**At this time, how much experience do you have with:**

1. E-learning or online learning in general? 1 2 3 4 5
2. Using online technology (e.g. email, internet)? 1 2 3 4 5
3. Case-based learning (learning from clinical cases)? 1 2 3 4 5
4. Small-animal cases in particular? 1 2 3 4 5

Please use the sliding scale to answer the following questions
from Not at all (1) to Extremely (10)

1. How motivated are you to participate in this course? 1 2 3 4 5
2. How motivated are you to achieve a high grade in this course?
In this section, we are interested in learning more about your **Attitude and Reaction** towards case-based e-learning in your upcoming course.

<table>
<thead>
<tr>
<th>Please rate your level of agreement from Strongly Disagree to Strongly Agree with the following statements</th>
<th>1</th>
<th>2</th>
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<tr>
<td>Scale: 1-5 (1 = Strongly Disagree, 2 = Somewhat Disagree, 3 = Neutral, 4 = Somewhat Agree, 5 = Strongly Agree)</td>
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<td><strong>At this point in time, I think:</strong></td>
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<tr>
<td>1. I will enjoy using the case-based e-learning tool to learn how to approach a clinical case</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2. I will enjoy using the case-based e-learning tool to learn how to apply my textbook knowledge (what you learn in lectures)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. I will enjoy using the case-based e-learning tool to learn how to apply my clinical knowledge (what you learn in practice)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>4. I feel confident using a case-based e-learning tool in my learning</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5. I feel confident learning from content presented online</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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<table>
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<td><strong>At this point in time, for this course, I think the case-based e-learning tool:</strong></td>
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<tr>
<td>1. Will help me in navigating through a clinical case</td>
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<td>2. Will allow me to learn more than I would in a traditional lecture</td>
<td>1</td>
<td>2</td>
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<tr>
<td>3. Will be a reliable method of instruction in this course</td>
<td>1</td>
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<td>4. Will give me confidence to approach a clinical case</td>
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<td>5. Could replace a real-case experience when learning how to approach a clinical case</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
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<td>6. Is a good bridge between traditional lecture-based teaching and learning from a real case</td>
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<td><strong>At this point in time, I think:</strong></td>
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1. I feel comfortable using an e-learning tool for my learning  
2. The case-based e-learning tool will be well designed and easy to use  
3. An online method of delivery of the cases is beneficial for my learning  
4. The technical aspects of using a case-based e-learning tool will limit or hinder my learning

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In this section we are interested in learning more about your **Learning Style** and **Perceived Learning Outcomes** when using case-based e-learning in this course.

**Please rate your level of agreement from Strongly Disagree to Strongly Agree with the following statements**  
*Scale: 1-5 (1 = Strongly Disagree, 2 = Somewhat Disagree, 3 = Neutral, 4 = Somewhat Agree, 5 = Strongly Agree)*

**At this point in time, I think:**

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**Please rate your level of agreement from Strongly Disagree to Strongly Agree with the following statements**  
*Scale: 1-5 (1 = Strongly Disagree, 2 = Somewhat Disagree, 3 = Neutral, 4 = Somewhat Agree, 5 = Strongly Agree)*

**Right now, I think the case-based e-learning tool will:**

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Page 3 of 8
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<th>through a case as a group</th>
<th>9. Motivate me to explore clinical topics in more depth</th>
<th>10. Promote working independently on the online cases</th>
<th>11. Improve my decision-making accuracy</th>
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<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>

Please rate your level of agreement from Strongly Disagree to Strongly Agree with the following statements
Scale: 1-5 (1 = Strongly Disagree, 2 = Somewhat Disagree, 3 = Neutral, 4 = Somewhat Agree, 5 = Strongly Agree)
Right now, I think a supervising professor:

<table>
<thead>
<tr>
<th></th>
<th>1. Will be a sufficient resource for any technical concerns while using the case-based e-learning tool</th>
<th>2. Must be actively involved in working through the online cases with the students</th>
<th>3. Should be available to answer questions related to the online cases, but does not need to be actively involved in working through them</th>
<th>4. Does not need to be present when working through the online cases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>

Which of the following below might motivate you to use the online e-learning tool?
Please respond on a scale of Not at all (1) to Extremely (10)

<table>
<thead>
<tr>
<th></th>
<th>1. I find lecture material is insufficient</th>
<th>2. I think the online cases will help better understand the lecture material</th>
<th>3. I think the online cases will help develop my critical thinking and problem solving skills</th>
<th>4. I think the online cases will teach me how to approach a clinical case</th>
<th>5. I prefer to use online resources/material over lecture material</th>
<th>6. I think the online cases are more practical than live animal cases</th>
<th>7. I think the online cases reliably represent live animal cases</th>
<th>8. I think working through the online cases will make me feel more like a real veterinarian</th>
<th>9. I think the online cases will allow me to work on my own time</th>
<th>10. I think the online cases are interactive</th>
<th>11. The online cases are mandatory</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>
Please indicate how important you believe the following elements are to maintaining engagement in the online cases from Not at all (1) to Extremely (10)

<table>
<thead>
<tr>
<th>The online cases must:</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Show a video of a real animal</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2. Show a picture of a real animal</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. Include sound</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>4. Show a complete case with all necessary steps from start to finish</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Include cost considerations for treatment plans</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

How often do you believe you will use the following resources to solve the online cases? Scale: 1-5 (1 = Never, 2 = Rarely, 3 = Sometimes, 4 = Often, 5 = Always)

| 1. Internet                                                                            | 1  | 2  | 3  | 4  | 5  |
| 2. Course lecture material                                                             |    |    |    |    |    |
| 3. Information from other classes                                                     | 1  | 2  | 3  | 4  | 5  |
| 4. Previous/current clinical experience (Select N/A if applicable)                     | N/A| 1  | 2  | 3  | 4  |
| 5. Consulting your peers                                                              |    |    |    |    |    |

Please rank your level of agreement from Strongly Disagree to Strongly Agree with the following statements Scale: 1-5 (1 = Never, 2 = Rarely, 3 = Sometimes, 4 = Often, 5 = Always)

<table>
<thead>
<tr>
<th>At this point in time:</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Working with my peers allows for a positive social environment</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2. I prefer to work by myself because I don’t want negative social repercussions from knowing less than my peers</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

In this section we are interested in learning more about what you think will be the **Outcome** in using a case-based e-learning tool in this course.

Please rate your level of agreement from Strongly Disagree to Strongly Agree with the following statements Scale: 1-5 (1 = Strongly Disagree, 2 = Somewhat Disagree, 3 = Neutral, 4 = Somewhat Agree, 5 = Strongly Agree)

<table>
<thead>
<tr>
<th>At this point in time, I think the case-based e-learning tool will:</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Help me understand the concepts taught in this course</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2. Help me achieve the learning outcomes of the course</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. Assist me in getting the best grade I can for the</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
Please rank your level of agreement from Strongly Disagree to Strongly Agree with the following statements
Scale: 1-5 (1 = Strongly Disagree, 2 = Somewhat Disagree, 3 = Neutral, 4 = Somewhat Agree, 5 = Strongly Agree)
At this point in time, I think the case-based e-learning tool will be effective at teaching me how to:

<table>
<thead>
<tr>
<th></th>
<th>1. Understand a patient history</th>
<th>2. Understand a physical exam</th>
<th>3. Create a problem list</th>
<th>4. Create a differential diagnosis list</th>
<th>5. Decide which diagnostics are most appropriate</th>
<th>6. Develop a treatment plan</th>
<th>7. Follow up with a patient’s treatment plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<td>5</td>
</tr>
</tbody>
</table>

Please indicate to what extent each of the following might increase your confidence in your abilities when using a case-based e-learning tool from Not at all (1) to Extremely (10)

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
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<tr>
<td>5</td>
<td>5</td>
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<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

Please indicate to what extent each of the following contributes towards your ability to retain knowledge from Not at all (1) to Extremely (10)
1. Associating information with an auditory cue (e.g. listening to a heart murmur)
2. Associating information with a tactile experience (e.g. doing a physical exam on a dog)
3. Discussing a complex concept with peers
4. Being able to apply information to a real life scenario
5. Reading information over and over again
6. Creating a visual representation of my knowledge (e.g. creating a concept map)
7. Other (Please indicate)

This section simply asks a few Demographics questions.

Please indicate your age
In whole numbers (e.g. 24)

My gender is
Please select one
Male
Female
Other

When I graduate I plan to practice in
Please select the ONE that best applies to you
Small Animal practice
Mixed Animal practice
Food Animal practice
Equine practice
Exotics
Undecided
Other (Please specify)

What is your primary spoken language?
Please select one
English
French
Other (Please specify)

First Name
This is used to compare pre-and post-questionnaire results

Last Name
This is used to compare pre-and post-questionnaire results

Congratulations! You have reached the end of the questionnaire. Please click ‘>>’ to ensure that your answers get recorded. DO NOT EXIT THE BROWSER BEFORE
CLICKING ‘>>’. Once you proceed, you will be automatically redirected to a short form that will enter you into the draw for the chance of winning various prizes.

If you do not wish to enter the draw, simply click ‘>>’ to ensure that your answers get recorded, the exit the browser.

Pre-Questionnaire Completion Draw – Contact Information

1. Full Name ______________________
2. Student Number__________________
3. Phone Number __________________

As a reminder, the information you enter in this draw are in no way associated with your responses from the questionnaire. The following information will solely be used for contacting you in case you are the successful winner of the draw.

This information will remain confidential and will not be included in any publication of the findings of this project. Once the draw is completed, it will erased.
Appendix F

Post- Case-Based E-Learning Use Online Questionnaire
Students’ Post Case-Based E-Learning Questionnaire

Thank you for agreeing to participate in this important survey. We are interested in learning more about your experiences after using a case-based e-learning tool (Articulate Storyline) in your course. Your responses to this survey will provide us with information to help with your learning experience in this course, and help to inform the veterinary literature on this important subject. Thinking about your experiences with case-based e-learning at this moment in time, please answer the following questions. Your responses here will NOT have any impact on your marks for this course.

1. BACKGROUND

What is your understanding of e-learning? (Please select all that apply)

<table>
<thead>
<tr>
<th>It involves:</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ Using an online platform (e.g. Courselink, Blackboard, etc.) to assist with lecture material distribution, tracking grades, etc.</td>
</tr>
<tr>
<td>□ Taking an online course</td>
</tr>
<tr>
<td>□ Learning using a computer</td>
</tr>
<tr>
<td>□ Learning using a tablet, smartphone, etc.</td>
</tr>
<tr>
<td>□ Learning from videos or audio recordings</td>
</tr>
<tr>
<td>□ Any learning delivered through the Internet</td>
</tr>
<tr>
<td>□ Working through online modules</td>
</tr>
<tr>
<td>□ Other (please specify) ____________________________</td>
</tr>
</tbody>
</table>

Please rate your level of experience with the following questions
(1 = No Experience, 2 = Somewhat Experienced, 3 = Moderately Experienced, 4 = Very Experienced, 5 = Extremely Experienced)

At this time, how much experience do you have with:

<table>
<thead>
<tr>
<th>1. E-learning or online learning in general?</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Using online technology (e.g. email, internet, etc.)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>3. Case-based learning (learning from clinical cases)?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4. Small-animal cases in particular?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5. Case-based e-learning (learning from online clinical cases)?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

2. ATTITUDE AND REACTION

Please rate your level of agreement with the following statements
(1 = Strongly Disagree, 2 = Somewhat Disagree, 3 = Neutral, 4 = Somewhat Agree, 5 = Strongly Agree)

At this point in time, I think:

| 1. I enjoyed using the case-based e-learning tool to learn how to approach a clinical case | 1 | 2 | 3 | 4 | 5 |
| 2. I enjoyed using the case-based e-learning tool to learn how to apply my textbook knowledge (what you learn in lectures) | 1 | 2 | 3 | 4 | 5 |
| 3. I enjoyed using the case-based e-learning tool to learn how to apply my clinical knowledge (what you learn in practice) | 1 | 2 | 3 | 4 | 5 |
| 4. I feel confident using a case-based e-learning tool in my learning | 1 | 2 | 3 | 4 | 5 |
| 5. I feel confident learning from content presented online | 1 | 2 | 3 | 4 | 5 |

Please rate your level of agreement with the following statements
(1 = Strongly Disagree, 2 = Somewhat Disagree, 3 = Neutral, 4 = Somewhat Agree, 5 = Strongly Agree)

At this point in time, for this course, I am satisfied with:

| 1. The number of cases available for my use | 1 | 2 | 3 | 4 | 5 |
| 2. The content presented and included in the case-based e-learning tool | 1 | 2 | 3 | 4 | 5 |
Please rate your level of agreement with the following statements  
(1 = Strongly Disagree, 2 = Somewhat Disagree, 3 = Neutral, 4 = Somewhat Agree, 5 = Strongly Agree)

<table>
<thead>
<tr>
<th>Statement</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Was helpful in navigating through a clinical case</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Allowed me to learn more than I would in a traditional lecture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Was a reliable method of instruction in this course</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Gave me confidence to approach a clinical case</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Could replace a real-case experience when learning how to approach a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>clinical case</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Is a good bridge between traditional lecture-based teaching and learning from a real case</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please rate your level of agreement with the following statements  
(1 = Strongly Disagree, 2 = Somewhat Disagree, 3 = Neutral, 4 = Somewhat Agree, 5 = Strongly Agree)

<table>
<thead>
<tr>
<th>Statement</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The case-based e-learning tool was well designed and easy to use</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. I feel comfortable using an e-learning tool for my learning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. An online method of delivery of the cases was beneficial for my learning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. The technical aspects of using a case-based e-learning tool limited or hindered my learning</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. LEARNING STYLE AND PERCEIVED LEARNING OUTCOMES

Please rate your level of agreement with the following statements  
(1 = Strongly Disagree, 2 = Somewhat Disagree, 3 = Neutral, 4 = Somewhat Agree, 5 = Strongly Agree)

<table>
<thead>
<tr>
<th>Statement</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I learn best by reading and memorizing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. I learn best by practicing and applying knowledge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. I learn best visually through videos and pictures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. I learn best by working in a group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. I am a hands-on learner and need to work on an actual case to understand clinical concepts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. The case-based e-learning tool satisfied my own learning style</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. The case-based e-learning tool changed my perceived learning style</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. After using the case-based e-learning tool, my preferred method of studying has changed</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please rate your level of agreement with the following statements  
(1 = Strongly Disagree, 2 = Somewhat Disagree, 3 = Neutral, 4 = Somewhat Agree, 5 = Strongly Agree)

<table>
<thead>
<tr>
<th>Statement</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Improved my critical thinking skills</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Enhanced my problem-solving skills</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Challenged me to apply previous knowledge to a case/problem</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Allowed me to remember various topics/concepts for a longer period of time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Helped me understand concepts rather than memorizing them</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Enhanced my understanding of concepts taught in the course</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Assisted in learning efficiently in the time I had</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Motivated me to interact with my peers when working through a case</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Motivated me to explore clinical topics in more depth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Promoted working independently on the online cases</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Improved my decision-making accuracy</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Please rate your level of agreement with the following statements
(1 = Strongly Disagree, 2 = Somewhat Disagree, 3 = Neutral, 4 = Somewhat Agree, 5 = Strongly Agree)
Right now, I think:

<table>
<thead>
<tr>
<th>Statement</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I preferred to work through the online cases on my own</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2. I learned successfully because I could work through the cases at my own pace</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. I learned successfully because I could work through the cases with support from my peers</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Please rate your level of agreement from with the following statements
(1 = Strongly Disagree, 2 = Somewhat Disagree, 3 = Neutral, 4 = Somewhat Agree, 5 = Strongly Agree)
Right now, I think a supervising professor:

<table>
<thead>
<tr>
<th>Statement</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Was a sufficient resource for any technical concerns while using the case-based e-learning tool</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2. Must be actively involved in working through the online cases with the students</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. Should be available to answer questions related to the online cases, but does not need to be actively involved in working through them</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>4. Does not need to be present when working through the online cases</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Which of the following below might motivate you to use the online e-learning tool?
Please respond on a scale of Not at all (1) to Extremely (10)
(Write number beside each corresponding question)

<table>
<thead>
<tr>
<th>Statement</th>
<th>__</th>
<th>__</th>
<th>__</th>
<th>__</th>
<th>__</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I find lecture material is insufficient</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
</tr>
<tr>
<td>2. I think the online cases helped better understand the lecture material</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
</tr>
<tr>
<td>3. I think the online cases helped develop my critical thinking and problem solving skills</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
</tr>
<tr>
<td>4. I think the online cases taught me how to approach a clinical case</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
</tr>
<tr>
<td>5. I prefer to use online resources/material over lecture material</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
</tr>
<tr>
<td>6. The online cases are more practical than live animal cases</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
</tr>
<tr>
<td>7. The online cases reliably represent live animal cases</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
</tr>
<tr>
<td>8. I think working through the online cases made me feel more like a real veterinarian</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
</tr>
<tr>
<td>9. The online cases will allow me to work on my own time</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
</tr>
<tr>
<td>10. The online cases are interactive</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
</tr>
<tr>
<td>11. The online cases are mandatory</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
</tr>
</tbody>
</table>

Please indicate how important you believe the following elements are to maintaining engagement in the online cases from Not at all (1) to Extremely (10)

The online cases must:

<table>
<thead>
<tr>
<th>Statement</th>
<th>__</th>
<th>__</th>
<th>__</th>
<th>__</th>
<th>__</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Show a video of a real animal</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
</tr>
<tr>
<td>2. Show a picture of a real animal</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
</tr>
<tr>
<td>3. Include sound</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
</tr>
<tr>
<td>4. Show a complete case with all necessary steps from start to finish</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
</tr>
<tr>
<td>5. Include cost considerations for treatment plans</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>__</td>
</tr>
</tbody>
</table>

How often do you believe you used the following resources to solve the online cases?
(1 = Never, 2 = Rarely, 3 = Sometimes, 4 = Often, 5 = Always)

<table>
<thead>
<tr>
<th>Resource</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Internet</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2. Course lecture material</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. Information from other classes</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>4. Previous/current clinical experience (Indicate N/A if applicable)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5. Consulting your peers</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Please rank your level of agreement with the following statements
4. OUTCOMES

<table>
<thead>
<tr>
<th>Please rank your level of agreement with the following statements</th>
<th>(1 = Strongly Disagree, 2 = Somewhat Disagree, 3 = Neutral, 4 = Somewhat Agree, 5 = Strongly Agree)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I would be inclined to use a case-based e-learning tool for future learning, studying, etc.</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>2. I used the e-learning tool primarily in lab for mandatory course activities</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>3. I used the e-learning tool outside of lab for personal use (e.g. studying)</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>

At this point in time, I think the case-based e-learning tool:

<table>
<thead>
<tr>
<th>Please rate your level of agreement with the following statements</th>
<th>(1 = Strongly Disagree, 2 = Somewhat Disagree, 3 = Neutral, 4 = Somewhat Agree, 5 = Strongly Agree)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Helped me understand the concepts taught in this course</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>2. Helped me achieve the learning outcomes of the course</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>3. Assisted me in getting the best grade I can for the course</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>4. Is/will be a good resource for me to practice the steps in approaching a clinical case</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>5. Is/will be a good study tool for any future courses/rotations</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>6. Allowed me to integrate knowledge from various courses to solve a case</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>7. Taught me to work collaboratively with my peers when approaching a case</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>8. Increased my confidence in my abilities to approach a clinical case</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>9. Increased my confidence in making clinical decisions</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>

At this point in time, I think the case-based e-learning tool was effective at teaching me how to:

<table>
<thead>
<tr>
<th>Please rank your level of agreement with the following statements</th>
<th>(1 = Strongly Disagree, 2 = Somewhat Disagree, 3 = Neutral, 4 = Somewhat Agree, 5 = Strongly Agree)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Understand a patient history</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>2. Understand a physical exam</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>3. Create a problem list</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>4. Create a differential diagnosis list</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>5. Decide which diagnostics are most appropriate</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>6. Develop a treatment plan</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>7. Follow up with a patient’s treatment plan</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>

Please indicate to what extent each of the following increased your confidence in your abilities when using a case-based e-learning tool from Not at all (1) to Extremely (10)

| Increased my knowledge retention | 1 |
| Applied knowledge to a real case | 1 |
| Navigating through a clinical case | 1 |
| Learning the process of a clinical case | 1 |
| Practicing critical thinking and problem solving | 1 |
| Integrating knowledge from other classes | 1 |
| Validation of knowledge | 1 |
| Demonstrating veterinary competencies | 1 |
Please indicate to what extent each of the following contributed towards your ability to retain knowledge from Not at all (1) to Extremely (10)

1. Associating information with an auditory cue (e.g. listening to a heart murmur) __
2. Associating information with a tactile experience (e.g. doing a physical exam on a dog) __
3. Discussing a complex concept with peers __
4. Being able to apply information to a real-life scenario __
5. Reading information over and over again __
6. Creating a visual representation of my knowledge (e.g. creating a concept map) __
7. Other (Please indicate) ____________________________ __

Please answer the following to the best of your ability (in whole numbers)

1. Estimate how many times you accessed the case based-e-learning modules to study for exams __

5. DEMOGRAPHICS

First Name (Used to compare pre-and post- questionnaire results) ____________________________

Last Name (Used to compare pre-and post- questionnaire results) ____________________________

Date of Birth (MONTH – DAY – YEAR) _____/____/____

When I graduate I plan to practice in (Please select the ONE that best applies to you)

- [ ] Small Animal practice
- [ ] Mixed Animal practice
- [ ] Food Animal practice
- [ ] Equine practice
- [ ] Exotics
- [ ] Undecided
- [ ] Other (Please specify)

Prize Draw Entry

Please fill out the following additional information should you choose to enter in to the prize draw.

Telephone Number _______________________

Email ________________________________