



## Impact of the internet on veterinary surgery

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### ABSTRACT

The advent of the internet, and the technological innovations associated with it, have driven significant advances in surgical teaching and learning. The ease of access to information and the variety of online resources allow rapid sharing of surgical knowledge, promoting new teaching and learning patterns. Educational content from online platforms adds theoretical and practical knowledge to accelerate the learning curve and continuing education of surgeons. This study reviews how the advent of the Internet has influenced the teaching and dissemination of knowledge in veterinary surgery.

### Abbreviations

VR, virtual reality;  
3D, three-dimensional;  
AR, augmented reality;  
COVID-19, coronavirus disease 2019;  
AESOP, Automated Endoscope System for Optimal Positioning;  
AI, artificial intelligence

### 1. Introduction

Since its emergence in the mid-1960s, the internet has developed exponentially, being a worldwide source of information for an increasing number of people from diverse fields and with wide-ranging levels of knowledge. From 1991, with the introduction of the World Wide Web, the sharing of information achieved global dimensions. Furthermore, the rapid development and popularization of internet technology has allowed development of a range of document formats such as video, audio, text, and images, that can be made available to millions of people simultaneously. Rapid dissemination of up to date information has revolutionized education (Lee, Cailliau & Groff, 1992).

The new technologies have enabled innovations in teaching and learning strategies. A number of studies have compared the use of internet-based online resources with conventional (face to face) education. Global access to quality information has expanded knowledge in diverse areas and revolutionized the field of veterinary surgery. These changes go beyond the physical barrier of conventional education and

allow access to constantly updated information on search engines, academic sites, online journals, e-books, videos, applications, social media, among others. This access allows for a broader knowledge of the best surgical indications for individual patients based on scientific evidence available worldwide. It also enables new surgical techniques to be learned from videos, online articles, or e-books. The exchange of experiences between surgeons in a fast, accurate, and practical way improves decision making, surgical treatments and produces better outcomes for the patient (Mayer, 2008; Ruiz, Mintzer & Leipzig, 2006).

In addition, the Internet has accelerated the development and spread of scientific research allowing up to date knowledge to be passed on from online resources with greater student interactivity. Information can also be collected on online platforms and used in the provision of e-Learning (Tarpada, Morris & Burton, 2016).

Although this education revolution is widespread there is little information on the applicability, efficiency and impact that the Internet has had on the teaching of veterinary undergraduate students or professionals. Nor is there information on the contribution made to the continuing clinical and surgical education of veterinarians. This study reviews how the Internet and technological advances have influenced teaching and knowledge acquisition in veterinary medicine, as well as its potential to influence development of veterinary surgery.

### 2. Access to information

The ease and speed of access to information has grown exponentially since the emergence of the Internet. In surgical education, access to

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online content has a positive impact on the ability to learn and fix knowledge in the long term, as well as accelerating the learning curve (Mayer, 2008; Tarpada et al., 2016).

Rapid access to explanatory videos of surgical techniques, the availability of tutorials, the practicality of distance classes, the exchange of knowledge facilitated through social media platforms, access to updated versions of e-books, in addition to scientific literature online allows broader and permanent knowledge acquisition. In a study using online questionnaires, 98% of 141 human surgeons from different specialties in Portugal (including urology, general surgery, orthopedics, gynecology, ophthalmology) stated a preference for using videos to prepare for surgical procedures (Mota et al., 2018). This trend can be extrapolated to veterinary surgeons, accounting for the thousands of video viewings of a diverse range of surgical techniques in animals, available on online video platforms. However, there are no studies that specifically assess the preferences of veterinary surgeons regarding preparation for a given surgical procedure.

Advances in the field of information and communication technology offer an opportunity to improve surgical education (Mutter et al., 2011; Pape-Koehler et al., 2013). The use of the internet, coupled with the availability of modern portable electronic devices, allows medical professionals to have rapid online access to the multitude of training tools, adding to conventional and individualized teaching. Additionally, multimedia resources enable this education to be more collective, globalized and accessible to all (Mota et al., 2018). In fact, studies in the field of psychology and learning science emphasize the importance of multimedia tools in the learning process. These tools aid the cognitive processing of information and subsequent integration of such information into existing knowledge, allowing the long-term fixation of knowledge. Such processing is complex, therefore, the dynamic approach to teaching, using multimedia resources (photos, videos, illustrations, diagrams, animations etc.) improves the learning process over the more passive model of conventional education (Mayer, 2008).

### 3. E-learning

#### 3.1. Concept

The term e-Learning refers to the online aspect of teaching and learning and encompasses the combination of multiple teaching methods such as tutorials, virtual analysis of clinical cases, videos, videoconference and online discussion. Several studies, particularly in human medicine, have demonstrated the effectiveness of these methods in the clinical-surgical educational context (Cook, Garside, Levinson, Dupras & Montori, 2010; Jayakumar, Brunckhorst, Dasgupta, Khan & Ahmed, 2015). Medical areas such as orthopedic surgery (Tarpada et al., 2016), cardiothoracic surgery (Aloia & Vaporciyan, 2019), plastic surgery (Martin-Smith, McArdle, Carroll & Kelly, 2015), head and neck surgery (Lee et al., 2018), endoscopy (Pimentel-Nunes & Buxbaum, 2017) and minimally invasive surgery (Ortega-Morán et al., 2017) have seen potential benefits from the introduction of technological advances, either to replace or complement traditional teaching.

The use of e-learning, in its most diverse modalities, brings benefits related to the flexibility of teaching, ease of content updates, reuse of material, reduced costs of labor, infrastructure, student and teacher travel (Ruiz et al., 2006). In the case of programs that include training with cadavers that requires a dedicated space, e-learning also avoids the high maintenance and material acquisition costs as well as legal/ ethical issues. The Internet and its associated technological advances can substantially reduce obstacles, allowing faster and easier access to teaching (Tarpada et al., 2016).

#### 3.2. Distance learning in veterinary medicine

E-Learning is gradually gaining ground in the teaching of veterinary medicine. The first distance learning programs accredited for veterinary

medicine were created in the late 90's in North America and similar programs are now used in universities seeking to create a dynamic and interesting learning environment (Bassert, 2006; Bill, 2007). It is too early to say how this new teaching model compares with the traditional one, but its limitations and potential are known (Bowen, 2020). This teaching method has gained popularity in the past decade, but its use in the medical field is patchy -since it seems to be more effective and is more frequently used in core scientific disciplines when compared to subjects that demand practical application (Bill, 2007).

In the context of teaching veterinary anatomy, a study showed that the method was well accepted and proved to be a useful and functional tool (Costa, Costa, & Olsson, 2019).

Several other disciplines such as parasitology, biochemistry and immunology have used e-Learning to provide a teaching alternative based on more interaction, motivation and contact with the material for the student (Boye, Moen & Vik, 2012; Kleinsorgen et al., 2018; Peña-Fernández, Magnet, Acosta, Evans & Fenoy, 2018).

With the advent of smartphones and easy access to the internet, students were already looking for remote learning resources to support their studies, thus, they consider e-Learning methods an integral part of their teaching model (Gledhill, Dale, Powney, Gaitskell-Phillips & Short, 2017). In addition, it is an interesting method for staff training, having been shown to be effective when used in teaching about emerging and reemerging animal diseases and zoonoses, for 450 veterinarians. The e-Learning in this study was effective for the rapid dissemination of knowledge and skills in a cost-effective way when compared to training these same 450 people in person. One of the great advantages of online training is the access for a large number of students who are out of reach of programs on the university campus (Alessandrini et al., 2012; Bill, 2007).

The distance education method has two important limitations, the first is the need for independence and commitment from student. The second limitation is that, even with the advancement of technology, e-Learning is not able to replace the need for practical teaching in veterinary medicine. However, this method can be considered an additional element of teaching, providing good learning efficiency when used alongside additional practice (Bates, 2005; Kelly, Mihm-Carmichael & Hammond, 2019).

#### 3.3. Teaching tools in teaching and learning veterinary surgery

The use of the internet offers benefits to development and learning in surgical disciplines, either through explanatory text, or images and videos of surgical procedures. As surgical techniques evolve and new technologies favor more effective surgical procedures, the modalities by which future surgeons are trained must also develop (Peycke, 2015; Wong & Matsumoto, 2008).

Surgical practice requires the surgeon to have knowledge of appropriate procedures, subtle techniques for tissue manipulation, confidence in tissue reconstruction with minimization of contamination and complications and be able to minimize surgical time. In most cases these techniques are skills are learnt through the mechanical practice of suturing, diaeresis and hemostasis, however, better online training may favor development of even more effective procedures (Peycke, 2015).

In addition to the content available on the internet, the development of virtual reality (VR) has proved a useful tool in many educational disciplines (Hunt, Heydenburg, Anderson & Thompson, 2020). Virtual reality apps can assist veterinary students to develop surgical skills. However, studies are needed to verify the effectiveness of this teaching method for surgical procedures, such as the studies of VR for the development of endoscopic skills (McCool, Bissett, Hill, Degernes & Hawkins, 2019), microscopy (Bertram, Firsching & Klopffleisch, 2018), or laparoscopic procedures, which also only had a small number of participants (Fransson, Chen, Noyes & Ragle, 2016). In the work of Hunt and collaborators (Hunt et al., 2020), the use of lectures and conventional surgical videos were as effective for the acquisition of surgical

skills as the use of VR by 29 veterinary students.

The use of video can enhance the realism and authenticity of the learning environment (Tiellet, Pereira, Reategui, Lima & Chambel, 2010). In this way, electronic media and the internet can provide surgical education in different locations, regardless of physical distance, and even in the face of limited resources. In the study by Autry and collaborators (Autry et al., 2013), the remote teaching of surgical techniques given online by professors from the Department of Obstetrics and Gynecology at the University of California, San Francisco, complemented the classes of intern doctors at the Mulago Hospital at Makerere University in Kampala, Uganda. These doctors showed a significant improvement in their score for technical suturing skills after the remote classes. Thus, similar partnerships between different universities could produce benefits for teaching veterinary surgery.

The study of videos at the time of the first surgery was reportedly used as the main refresher of the surgical technique for about 60% of 108 veterinary students. During the preparation period these students had access to face-to-face classes, support material such as slides narrated online, books, training models, training on cadavers and online videos. Of the 112 students, 45 did not use textbooks as preparatory study material and when they did, about 42 students spent an hour studying textbooks, while approximately 46 students spent about three hours studying surgical videos (Langebæk, Nielsen, Koch & Berendt, 2016).

One of the objectives of the work developed at the Federal University of Santa Maria was the creation of a non-linear interactive medium, in which video integrated with other media supported the acquisition of surgical knowledge, individually or in groups. Students who had access to the hyper-video felt more confident to perform the surgical procedure, while the teachers reported that there were fewer frequently asked questions in theoretical and practical classes, after students had watched the hyper-videos (Tiellet et al., 2010).

Three-dimensional (3D) animation tools have been developed and used in research and teaching of veterinary surgical techniques (Asma & Eddine, 2014). 3D animation proved to be an effective method for the obstetric teaching of dystocic births in horses (Gao et al., 2020). They also provided students and dog owners with better understanding of functional anatomy and mechanisms of joint stability with different surgical techniques for correction of cranial cruciate ligament rupture (Clements et al., 2013).

In a course on surgical techniques in laboratory animals for undergraduate and graduate students the acquisition of knowledge was comparable whether courses were conducted in person and online. The students preferred videos, photographs and a step-by-step description of the surgical procedures, however, they warned of the need for better resolution of the videos and quality of the narrations (Baran, Johnson, Kehler & Hankenson, 2010). Among the limitations commonly observed in the development of online studies are the resolution of videos and images, and problems with internet connection (Baran et al., 2010; Tiellet et al., 2010).

The benefits and advantages of Internet use do not invalidate classroom teaching technologies, such as training in surgical models. The use of which is associated with less stress and anxiety, as well as less surgical time when veterinary students perform the first ovariohysterectomy (Annandale, Scheepers & Fosgate, 2020).

### 3.4. Digital simulation in surgical teaching

The use of live animals for experimental surgeries or surgical training for veterinary and medical students has been reduced (Smeak, 2007), which has resulted in a rise in the use of cadavers (Pochat et al., 2011; Singh, Scott, Case, Mayhew & Runge, 2019), synthetic models (Grimes, Wallace, Schmiedt & Parks, 2019), and software (Mandler, 2018). Technological advancement aims to improve the quality of care for patients in many medical areas (Skinovsky, Chibata & Siqueira, 2008). Such tools have become essential in learning and, thanks to the

evolution of technology associated with the implementation of simulation applications, professionals can improve their medical skills and, consequently, mitigate errors without the use of live animals (Moss, 2017).

Surgical planning and augmented reality (AR) are critical and useful tools within a surgical center (Valdes, Roberts, Lu & Golby, 2016). When using AR, medical images can be manipulated to accurately plan surgery in a virtual environment, which can then be translated to the patient (Bernardo, 2017). In veterinary medicine integrated RA technology is still rarely used, but good results have been obtained (Lee et al., 2013), making it a viable alternative for training students by accelerating the learning curve and reducing the use of live animals.

In human medicine the 3D surgical applications of VR use computing technologies to simulate life in its natural environment (Moss, 2017). They allow the operator to have a live experience prior to the procedure, permitting practice and reducing the errors, thus improving the surgeon's confidence and performance (Bernardo, 2017; Ruisoto, Juanes, Contador, Mayoral & PratsGalino, 2012). Such navigation software can assist inexperienced surgeons in surgical training. Legal and ethical concerns limit the number of surgeries available to inexperienced surgeons for training (Skinovsky et al., 2008). If surgeons have access to training based on software, their skills should increase, giving them a broader choice of surgical approaches, available techniques, surgical alternatives and facilitating problem solving, which will improve the postoperative prognosis for each patient (Bernardo, 2017; Skinovsky et al., 2008).

VR provides a sensory experience similar to reality. Outside the medical field it is primarily used in aviation and military training, as it allows the operator to live with dangerous situations before witnessing them in practice (Wojciechowski & Blaszczyk, 2019). Simulations in biological systems bring positive feedback on learning, enabling repetition and objective assessment (Bernardo, 2017). Currently, simulators allow you to experience tactile sensations from different tissues, known as biofeedback, bringing virtual practice even closer to reality (Skinovsky et al., 2008).

"TouchSurgery" is a free and interactive software that provides human surgeons with realistic simulations of cognitive motor skills and surgical steps based on theory (Sugand, Mawkin & Gupte, 2015). Satisfactory results have been shown in the professional's practical application (Tulipan, Miller, Park, Labrum & Ilyas, 2019). The use of technology in surgical training directly impacts patient care, with a resource capable of expanding and facilitating access to information regarding rare and routinely performed procedures.

In the same way, it provides new and effective ways of training as well as access to simulated surgical procedures, improving surgical education (Ozdalga, Ozdalga & Ahuja, 2012).

According to the study by Bunogerane and colleagues (Bunogerane, Taylor, Lin & Costas-Chavarrri, 2018), applications such as TouchSurgery bring better professional development in human surgical procedures, teaching better skills and dexterity. However, theoretical knowledge must be preceded by sound theoretical knowledge based on books and scientific articles.

Finally, the use of new digital applications that improve the teaching of professionals will reduce the current limitations, such as teachers' time for face-to-face classes, difficulties associated with use of live specimens or cadavers, as well as the reduction in use of consumables (plates, sutures etc.), which represent a high cost for the necessary training.

### 3.5. Online and printed resources: how online technologies can influence clinical and surgical knowledge and practice

Medical education, which previously spent centuries stuck in the mold of traditional teaching, based on physical books and face-to-face teaching has been revolutionized by technological evolution (Guarino et al., 2014). Internet-related technologies, such as tablets, smartphones,

computers, artificial intelligence, allow wide distribution of digital content to multiple users simultaneously, and can serve users at any time and place (Ruiz et al., 2006). However, rather than replacing conventional teaching, such advances can be used as tools to complement it.

In a questionnaire completed by 350 medical students, the traditional study mode based on reading books, face-to-face classes, and notes remained the main resource for learning new content (Wynter, Burgess, Kalman, Heron & Bleasel, 2019). Guarino and colleagues (Guarino et al., 2014) also concluded that medical students found books to be more useful tools than lectures, internet and offline multimedia content. It is now common practice for students and medical professionals to search for content in e-books, virtual libraries, Google, YouTube, Wikipedia, social media and online lectures, giving students more autonomy but potentially facilitating too much access to information (Han, Nelson & Wetter, 2014; Wynter et al., 2019). However, although the internet is a valuable source of medical information, traditional books still play an important role in medical education. The availability of scientific books and journals online has increased access to published scientific data. Similarly, researchers can publish their results more quickly and effectively and to a greater number of people than when physical books and journals were the main resources available. Such advances have boosted education, and online text queries are now indispensable for maintaining and developing the current scientific knowledge.

Technological developments in the field of diagnostic imaging have increased the detail of imaging examinations, improving early diagnosis of diseases and contributing to better surgical planning. For example, the acquisition of digital radiographic images coupled with the use of dedicated software maximizes the quality of diagnostic images. Digital images can be stored on computers and become instantly available to hospital professionals, or they can be transmitted via the internet and accessed at any time or place, without the need to print radiographic films (Mattoon, 2006). The use of apps and computer programs allows such digital images to be used in surgical planning, for example in selecting appropriately sized orthopedic implants, or for evaluation of the extent of neoplasms. Each surgeon plans surgery depending on individual preferences and available resources.

#### 4. Work on communication networks, partners and multicenter trials

Communication skills are essential for the exchange of information and knowledge and for the interaction between doctor and patient/client. Technological advances have been improving communication processes and changing all aspects of people's daily. Connections between satellites and ground stations allow communication to be practically instantaneous, meaning distance or physical barriers offer no obstacles for the transmission of information. Therefore, web connectivity offers rapid information sharing through technology, whether by computer, mobile, social media, facilitating knowledge sharing (Kates, Samuels, Case & Dujowich, 2020; Saravanan, Rajan, Venkatraman, Sriraam & Murugan, 2011).

The development of communication methods and modern information technologies has paved the way for the advent of telemedicine - providing medical advice to patients and other health professionals at distant sites. Remote consultations provide better access to care, reduce costs and improve patient satisfaction (Craig & Patterson, 2005; Granja, Janssen & Johansen, 2018). Furthermore, recent concerns related to the coronavirus disease 2019 (COVID-19) pandemic have highlighted other benefits of telehealth (Makhni, Riew & Sumathipala, 2020).

Telemedicine has grown exponentially since 1950 and currently has a global market share of about US\$ 38.3 billion. All disciplines, including surgery professionals, are interested in the use of telemedicine in perioperative care where it has shown excellent clinical results, good patient satisfaction and is economically advantageous (Forbes, Solozano & Concepcion, 2020; Makhni et al., 2020).

In the study by Paquette and colleagues (Paquette, Lin & Michigan, 2019) the benefits of telemedicine were shown through retrospective analysis of the impact of conventional outpatient services compared to telemedicine. The investigation considered the patient's travel expenses and environmental impacts. Telemedicine saved two years' time, decreased travel costs, and provided huge environmental benefits by reducing emissions of greenhouse gasses and pollutants.

For patients living in distant cities or in rural areas geographic barriers can also be overcome through telemedicine. The study by Wang and colleagues (Wang, Rajaratnam, Stall, Hawa & Sockalingam, 2019) demonstrated this by comparing post-consultation, psychosocial adherence and body mass index in bariatric surgery patients, with and without access to telemedicine. Despite having limited access to health services in a rural area, telemedicine users had adequate recovery after surgery, good compliance with attending consultations, and expected body mass index and psychosocial results equal to those who physically attended follow-up. Thus, the authors concluded that telemedicine can also help to overcome geographical barriers, providing a quality health service in remote locations.

Although technological communication has evolved, there are still challenges to overcome, for example e-mail overload, increased work interruptions and communication failures. An effective communication is needed to reduce access to incorrect and excess information. The pilot study by Kates and colleagues (Kates et al., 2020), evaluated whether a messaging application can improve communication between the surgical team in a veterinary hospital. All work was made accessible in a digital environment and in real time over a three-month period. There were times when duplicate messages were sent or communication was absent, showing changes to communication habits are needed for optimal performance of enhanced digital communication.

#### 5. Surgery and social networks

We live at a moment where e-Learning is one of the most important educational movements in history (Peters & Besley, 2008). The ability to access any content, allows information to arrive in an easy way almost everywhere. With free access to open educational resources veterinary medicine has huge potential to evolve (Sawras, Khosa, Lissemore, Duffield & Defarges, 2020). Social networks (eg Facebook, Instagram, YouTube, Google), are widely used platforms in the professional field, providing an environment for the display of technical and practical content, as well as facilitating the interaction of groups of people for classes, lectures and real-time courses (Singhal, Jambunathan, Manrai, Awasth & Sashindran, 2019).

The contribution of social networks in veterinary surgery is significant, particularly since content is almost always free of charge. Graduated students and veterinarians can follow case reports and discussions, research developments, interactive videos and lectures through videos in real time (Sawras et al., 2020; Sezer, 2016). Although it is difficult to assess how much content is absorbed by students, the ease with which digital enquiries are made makes learning effective, especially for students and professionals who feel intimidated in classes or in person lectures (Sezer, 2016).

There are some disadvantages to the use of social networks for sharing medical content, for example, there are risks associated with giving everyone free access to information and providing technical tools that would allow anyone to perform procedures that are the responsibility of the veterinarian (Garbin, Ortega, Garbin & Saliba, 2018; Gondim, Gondim, Macêdo & Azevêdo, 2019). Another problem is the ethical concerns associated with online exposure of patients, tutors, and of professionals (Gondim et al., 2019). The dissemination of veterinary medical content on social networks can increase general knowledge, but students must evaluate the information (and its source) carefully, since not all available content will be accurate or up to date.

## 6. Videosurgery and robotics in veterinary surgery

Advances in veterinary surgery have risen to new heights over the past decades. Videosurgery techniques have been performed for many years in human medicine and have gained popularity in veterinary medicine. They give surgeons the ability to perform surgery with smaller incisions and less postoperative pain, which reduces hospitalization costs and favors the animals' early return to normal life. However, despite its advantages, this modality requires a highly specialized team, as these procedures are not straightforward to perform and have a steep learning curve, due to the need for two-dimensional visualization equipment and the specific instruments required. When this technology was first used there were a large number of iatrogenic injuries in patients, due to the lack of experience and training of the surgeon. In addition, the cost of acquisition of the necessary equipment is very high and its use remains limited to a few specialized centers (Gallagher, Lederman, Mcglade, Satava & Smith, 2004; Gyles, 2019).

The new technology in human medicine today is robotic surgery, which takes video surgery to a new level. This technology was developed to meet the need for the great precision and refinement that is expected in certain techniques. Pre-determined movements using mechanical arms eliminate the need for human manipulation with its associated tremors and exaggerated movements that can occur in delicate surgeries (Gallagher et al., 2004; Lis, Lehrich, Mucha & Nawrat, 2017; Marescaux & Solerc, 2004). This technology has been tested in two ovariohysterectomies in bitches using the robotic arm AESOP (Automated Endoscope System for Optimal Positioning) at the Veterinary Hospital of the State University of the North Fluminense Darcy Ribeiro, but a number of other cameras and arms are under development around the world. Although this technology provides an effective, accurate and reliable experience, surgical time is much longer than for the open technique. More recently, a radical robot-assisted prostatectomy was performed in which the surgical time was reduced and the result was extremely satisfactory. As the technology becomes more mainstream, equipment acquisition costs should reduce and this technique can indeed become applicable to routine veterinary medicine. However, more studies are needed for every new technology to validate its real contribution to the veterinary field (Oliveira et al., 2013; Schlake et al., 2020).

## 7. Positive and negative aspects of the internet in the teaching of veterinary surgery

Online education has become increasingly popular for undergraduate courses in recent years, but the methodology is not new, instead being a version of distance education present in higher education (Mayadas, Bourne & Bacsich, 2009). Higher education institutions have found online education to be a solution to limited physical capacity and reducing budgets, providing greater access to relevant content anywhere and anytime. They also allow students to work at their own pace and with automatic feedback through online management systems which can identify student weaknesses (Blau et al., 2018).

However, concerns have been raised, mainly by the lecturers who need to find new methodologies to apply online and have difficulties in using online tools, but also there are concerns about the increasing workload of students, maintenance of academic integrity and how to maintain control and coherence of online content (Blau et al., 2018; Seery, 2012). Another disadvantage of online education is that when there are low-income and unprepared students, higher drop-out rates are seen from online classes than in face-to-face teaching, making access to education more difficult (Cooper & Stowe, 2018).

The student-teacher relationship has a direct influence on student learning and this interaction is reduced in online teaching. Despite this, in the exploratory and descriptive study by Ertmer and Koehler (Ertmer & Koehler, 2018), the interaction of teacher and students online and in face-to-face discussions was compared. It was concluded that although

the two methods were different the objectives of social cohesion and knowledge acquired by students were met in both.

Furthermore, academic motivation or reasons for involvement in tasks are important predictors of academic success (Jones & Issroff, 2005). In the study by Francis and colleagues (Francis, Wormington & Hulleman, 2019) in which students' motivation in online and face-to-face courses were compared, it was found that although academic results were different, academic motivation depended only on the characteristics of each student. Therefore, the teaching delivery method does not influence the student's motivation.

## 8. Perspectives: artificial intelligence and "big data"

The technology has been breaking barriers and solving challenges found in medicine. Artificial intelligence (AI) is able to predict and solve problems and build mechanisms that simulate human thinking. Since 2016, China has been conducting research in AI labs and these advances have already arrived in the online gaming industry. In June 2019, the USA created a Joint Artificial Intelligence Center, facilitating AI research by investing US\$ 2 billion over five years (Kim, Kelley, Nasser & Chung, 2019).

Big data is the term used for larger volumes of data that can be manipulated by management tools in which area AI may find a role (Kanevsky et al., 2016; Knight et al., 2019). Precision medicine is individualized and evidence-based medicine which incorporates genetic data, allowing individualized and prevention strategies, integrating specific patient data such as lifestyle, genetic characteristics and external influences. For this, advanced technologies must be able to classify and process vast amounts of data. AI is capable of gathering huge volumes of data, recognizing patterns and generating algorithms that assist the physician in care and show current health status. Although doctors are able to interpret such data manually, the quick and efficient data analysis by AI demonstrates the benefits of implementing this future technology (Kanevsky et al., 2016; Kim et al., 2019).

Medicine based on integration of AI and "big data" techniques promises great leaps in medicine and surgery, allowing us to capture details of precision medicine. The algorithms of artificial neural networks will analyze large-scale data and will recognize patterns and quickly quantify and distribute this information to surgeons.

With the implementation of AI and "big data", it will be possible to access integrated health data from every country and machines will be able to perform evidence-based diagnosis and request more accurate tests and determine need for hospitalization and indications for surgery, thus improving service and preventing human errors. The promise of AI and precision medicine is to provide technological power and revolutionize medicine in general (Kim et al., 2019; Knight et al., 2019).

## 9. Conclusion

The constant advances of the Internet in the development of veterinary surgery can be perceived in many ways, whether in improvements in training, communication between professionals or the development of new surgical techniques. It is clear that technological innovations have revolutionized the way we approach patients, and the resources currently available need to be used, whenever possible, to improve health care for both human and veterinary patients.

## 10. Ethical statement

Hereby, I /insert author name/ consciously assure that for the manuscript /insert title/ the following is fulfilled:

- 1) This material is the authors' own original work, which has not been previously published elsewhere.
- 2) The paper is not currently being considered for publication elsewhere.

- 3) The paper reflects the authors' own research and analysis in a truthful and complete manner.
- 4) The paper properly credits the meaningful contributions of co-authors and co-researchers.
- 5) The results are appropriately placed in the context of prior and existing research.
- 6) All sources used are properly disclosed (correct citation). Literally copying of text must be indicated as such by using quotation marks and giving proper reference.
- 7) All authors have been personally and actively involved in substantial work leading to the paper, and will take public responsibility for its content.

The violation of the Ethical Statement rules may result in severe consequences.

I agree with the above statements and declare that this submission follows the policies of Solid State Ionics as outlined in the Guide for Authors and in the Ethical Statement.

### Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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