Towards a Humane Veterinary Education

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ABSTRACT
There is a vast array of learning tools and approaches to veterinary education, many tried and true, many innovative and with potential. Such new methods have come about partly from an increasing demand from both students and teachers to avoid methods of teaching and training that harm animals. The aim is to create the best quality education, ideally supported by validation of the efficacy of particular educational tools and approaches, while ensuring that animals are not used harmfully and that respect for animal life is engendered within the student. In this paper, we review tools and approaches that can be used in the teaching of veterinary students, tools and approaches that ensure the dignity and humane treatment of animals that all teachers and students must observe as the very ethos of the veterinary profession that they serve. Veterinary education has not always met, and still often does not meet, this essential criterion.

INTRODUCTION

An important element of the veterinarian's role will always be to protect animals—a parallel to the physician's imperative, *primum non nocere* (first, do no harm). However, although many students are drawn to the veterinary profession by their compassion for living beings, some who are highly motivated to work in animal care may choose to avoid veterinary education because it once typically involved, and in many cases still does involve, animals' being killed for dissection and/or used live to demonstrate a variety of biological principles and teach practical clinical skills. Not only can these uses of animals present a barrier to otherwise dedicated students; they are also contrary to the ethos of the profession.

Advocates of such harmful animal use have argued that it enables understanding of subjects such as anatomy and physiology and assists in the mastery of some clinical and surgical skills. However, there are other ways of fulfilling these aims and delivering a good scientific education that provides the student with the skills, knowledge, and understanding required for the veterinary profession. Moreover, scientific knowledge and clinical skills are not all that are required of veterinarians. As professionals, veterinarians must understand animal behavior and appreciate all the aspects of pain and emotion that lead to animal distress. They must also be able to deal with animal guardians, often in difficult circumstances such as the loss of a loved companion animal. As future veterinarians, they must also be prepared for the increased focus on animal ethics in society. Such challenges require a well-developed sense of compassion, which the harmful use of animals in veterinary education is unlikely to promote. In this article, we outline a range of alternative teaching methods designed to provide students with veterinary knowledge and skills within a framework of humane education. We also give examples of how these methods may be incorporated into the curriculum.

DEFINITION AND TYPES OF ALTERNATIVES

Many scientists are implementing the 3Rs (reduction, replacement, and refinement of animal experiments), as defined by Russell and Burch,[1] using alternative approaches that improve animal welfare while maintaining and/or enhancing scientific rigor. The 3Rs, however, are not directly appropriate for veterinary medical education because they are rooted in the use of laboratory animals for research and testing, not in knowledge and skills acquisition. The ideal replacement alternatives in education may be non-animal, but it may equally involve animals. For example, students need the experience of handling animal tissue and living animals, including learning to perform invasive surgery and other clinical procedures. This training can and should be achieved by fully replacing conventional animal experimentation or other harmful procedures with the alternative of neutral or beneficial work with animals. As well as helping to meet practical teaching objectives, alternatives to harmful animal use also ensure that students do not acquire undesirable attitudes towards animals, such as an indifference to animal life and/or a disrespectful attitude towards animals as patients. Moreover, some necessary elements of veterinary education, such as training in patient care and understanding species-typical behavior, are likely to be undermined if there is harmful use of animals in the students' training.

The definition of alternatives within life science education can, therefore, be made stricter than that of the 3Rs, so as to comprise only replacement alternatives, and can be broadened to include approaches that involve neutral or beneficial work with individual animals. Alternatives in the context of this paper are humane educational aids and teaching approaches that can replace the harmful use of animals, including termination of life and euthanasia that does not stem from a medical situation. This definition is consistent with the underlying reason for working with and using animals in veterinary training, namely to produce professionals who have the knowledge and skills to care for animals and protect their well-being. The definition also reflects current possibilities and opportunities for replacement of harmful animal use in teaching.

In veterinary medicine and animal sciences, the major alternatives to harmful animal use in teaching comprise the use of models, mannequins, and simulators; the use of multimedia-computer simulation, including virtual reality; and the use of ethically sourced animal cadavers and tissue. Many of these approaches are used in multiple phases of veterinary and other health sciences education. Each can be

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complemented by humane, directed activities, such as clinical work with animal patients, and by the field studies that are also part of the curriculum in most veterinary education programs but that could replace some harmful animal use if extended in scope.[2] Film and video and *in vitro* labs can also play a role in replacement. The authors address in detail four types of alternatives to harmful animal use in veterinary education and explore the degree to which these alternatives can enhance teaching through better meeting teaching objectives. Individual models and suppliers for many of the aids are listed in Jukes and Chiuia.[2] Another paper[3] among the *theme papers* in this issue of the journal provides an extended discussion of the educational advantages evident in the use of simulators.

1. Models, Mannequins, and Simulators

These alternatives comprise synthetic training objects—designed to replicate or simulate organs, limbs, or whole animals—and apparatuses for simulating physiological functions and for the teaching of clinical skills, including those required in critical care.

Plastic models showing animals' internal structure are commonly used for teaching morphology; in orthopedics, plastic bones are widely used to illustrate fractures. Real animal cadavers that are ethically sourced can be used in similar fashion, through being dissected and then preserved by embalming and by techniques such as plastination.

Mannequins (or phantoms) are life-like representations of animals or humans, designed for clinical-skills training. Within veterinary medicine, mannequins can facilitate training in handling, blood sampling, intubation, thoracentesis, and CPR techniques. For difficult procedures such as the urinary catheterization of female dogs, anatomically correct mannequins can allow the student to follow the visual and tactile clues for the technique. Technically demanding procedures and those involving risk or stress to an animal can, therefore, be mastered by students without use of live animals, and critical care cases can be explored in advance. The computerized mannequins that are now becoming extensively available for human medical education[3] are still rare within veterinary medicine, but the latest Critical Care Jerry canine mannequin[4] integrates a digital heart and breath sounds simulator, as well as providing opportunities for practicing intubation, CPR, IV access, and other skills. The mannequins that are now available for human medical education, moreover, also provide excellent opportunities for the acquisition of clinical skills by veterinary students.

Simulators are tools for surgery, critical care, and some clinical-skills practice. Simulators range from suture trainers and surgery training devices to computerized ''patients.'' Simple and inexpensive simulators are often employed for simple skills acquisition—for example, psychomotor and other skills, including eye–hand coordination, instrument handling, and suturing. Simulated skin, hollow organ and intestinal anastomosis simulators, microsurgical trainers, and others are made from specially prepared plastics or latex to simulate the relevant tissue or organs realistically. Like mannequins, such simulators can give students more freedom to practice at their own rate, to learn by trial and error, and to repeat procedures, without high cost to animals.

Human patient mannequins and simulators are used in some countries for training students and professionals in clinical skills and procedures, as well as in critical care.[5] The most advanced of these mannequins have artificial skin, bones, and organs, a pulse, and artificial fluids simulating blood and bile. Computerized, they can present real-time emergencies and allow for real-time monitoring of how successful the trainee is in his or her performance of critical care or surgery. ''Drugs'' can be injected and the computer then creates the simulation of dose-dependent physiological responses. Trainee surgeons and other veterinary student ''doctors'' can, therefore, learn in an environment that is risk-free for animals, and the monitoring can also help ensure consistency and uniformity of training.

One mid-range surgery simulator, the Pulsating Organ Perfusion (POP) Trainer,[6] used for minimally invasive surgery training, can accommodate animal organs that are perfused and practiced on. The simulation can be used especially well for training in the management of bleeding. Students can train for as long as they want, with no animal being harmed. The experience of using the POP Trainer has been that trainees will often spend extra hours to further develop their skills. An advanced simulator developed at the University of Arkansas[7] employs perfusion of a human cadaver to offer a realistic alternative to live surgery. The veins and arteries are dynamically filled with colored liquid by a specially designed pump. This also applies pulsating pressure which can be transmitted to the vessels and thereby reliably simulate the vascular tree, all within a closed system. Dissection and a range of surgical and microsurgical approaches such as vascular suturing, anastomosis, and repair, intra-parenchyma resection, bleeding management, and endoscopic procedures can all be performed. Realistic surgery can therefore be practiced and the technique potentially be applied to both human and animal cadavers.

Used to their full potential, and as ever more sophisticated models become available, mannequins and simulators are allowing for considerable mastery of skills, not just exposure to them. By allowing repeated practice in an environment conducive to learning, the use of these specially designed tools can help students gain the necessary confidence and competence before working with patients. Aboud and colleagues[7] have suggested that ''utilising these techniques could forever eliminate the use of live anaesthetised animals for surgical training.''

2. Multimedia Computer Simulation

Computer technologies have revolutionized science and created many new opportunities for effective life-science education. Examples include virtual dissections and experiments in well-equipped laboratories that students can perform on screen, and full virtual reality (VR) simulations of clinical technique, with tactile facilities. The potential of computer-assisted learning to help students better visualize and understand structure and process, experiment and learn problem-solving strategies, and even practice clinical skills is limited only by the power of the computer and our own imaginative boundaries. A set of papers has recently been published by this journal[8] that covers a wide variety of computer uses in veterinary education.

Well-designed educational software can encourage a high conceptual level of understanding as well as increase understanding of the specific topics being addressed. In particular, the software can encourage self-directed exploration and problem-solving strategies that support initiative, creativity, and scientific thinking. Such active learning is likely to be highly effective because it is firmly grounded in the student's own experience. The innovative nature of new technological developments, such as multimedia software, can be exciting for students and teachers alike, which adds to the learning experience and is an important part of informal training for veterinarians for whom computer skills now play an important role. Nevertheless, computer simulation should always be complemented by non-harmful practical experience with live animals, so that technology is kept as a powerful tool, not an alternative to reality.

In a virtual dissection or anatomy program, students can perform tasks at their own pace, repeating as necessary. The range of facilities varies between programs. They may include libraries of color photographic images, with gross anatomy and histology that can allow a comparison between species. The user can spin organs and highlight different organ systems, and physiological processes such as digestion can be presented through animations, ''morphing,'' or video clips. Text information and opportunities for self-assessment may also be provided. These approaches, available on demand in the simulation, can provide a very rich and sensory experience to significantly enhance the quality and depth of learning.

One anatomy program that uses modern technology very successfully to enhance learning is ProDissector Frog.[9] This innovative program offers the capability of controlling the opacity of organ systems within a composite layered image so that their spatial relationship can be effectively visualized. Tags label and describe all the relevant anatomical features. Future programs will include more species commonly used within veterinary medical education. Multimedia software that includes a virtual laboratory presents a range of equipment on screen and may offer a very high degree of interactivity. Typically, such programs simulate classical animal preparations and experiments, with an emphasis on physiology, pharmacology, and critical care. These disciplines lend themselves well to multimedia because of the need to correlate multiple and simultaneous events and to gain an understanding of the interplay between complex and related phenomena. Virtual laboratories provide practice-oriented tasks, building on students' theoretical knowledge, with students actively performing experiments themselves. Students do so by using simulated tissue responses to stimuli or pharmacological agents as they would in an animal practical or clinical scenario, while monitoring and recording data with on-screen oscilloscopes and other apparatus. This can be in real-time or adapted to requirements. Various parameters in the experiments can be modified by users to generate data sets for analysis, and there may be options for different levels of complexity within one program. The responses themselves may include random variables to simulate biological variability. Some simulations enable the illustration of concepts (e.g., the effects of breathing low oxygen concentrations) or the performance of tasks that would be unethical, difficult, or impossible in the real situation.

In the early 1990s, in response to students' conscientious objections, Braun and co-workers[10] created a Virtual Physiology Series of alternatives, from which it was apparent that rapidly developing computer techniques could provide an opportunity to make virtual laboratories where the students could do experiments in a manner analogous to that in a real laboratory. These programs can exactly reproduce the experiments previously done with real animal preparations. According to Braun,[10] ''It is my impression and that of other tutors that teaching has become not worse but more effective.'' Some good examples of such software are available from cLabs and from Thieme Publishers.[11,12]

3. Virtual Reality

The term ''virtual reality'' (VR) generally refers to advanced interactive software, with powerful 3-D graphics, that often immerses the user within the experience, allowing psychomotor skills and procedures to be practiced in a highly sensory manner. In this exciting and rapidly growing field, the use of new technologies dramatically increases the opportunities for real-time interaction with a dynamic model of reality, through the computer–human interface. One of the most advanced uses of VR-based training is for flight simulations, due to the obvious practical–ethical limitations of real-life training; such simulations have become extremely important to the effective training of pilots. The adoption of VR approaches by the medical profession is driven by the same concerns about ensuring expert training and by the growth of innovative, minimally invasive diagnostic and therapeutic techniques well suited to VR simulation. Typically, the trainee practices by holding a wand, which represents a needle, scalpel, or endoscope, and performs the required procedure on the virtual patient. The software images the anatomy and tracks the movement of the instrument in real time. As well as visual feedback, that of *haptics*, the tactile sense that can be simulated in VR, is playing an increasingly important role. Data gloves offer resistance, as the proxy instrument interacts with the virtual patient's body. This force feedback means that challenging techniques such as negotiating a needle around a vein or maneuvering a catheter into the coronary arteries can be practiced and improved upon.

Most health sciences education VR so far has been used for skills enhancement for physicians, particularly to teach endovascular and endoscopic techniques. The approach has been applied less often within undergraduate medical and veterinary medical education, but VR within medical student education is gaining in use. Computer scientists, in collaboration with a small number of veterinary colleges, have developed trial VR simulations for enhanced clinical-skills acquisition and surgery practice. The University of Glasgow Veterinary School has been developing alternatives to invasive examinations on animals as part of its commitment to animal welfare and to ensuring better training for students. Its horse ovary palpation and haptic cow simulators[13] allow students to practice palpation without risking harm to the animals, as well as providing a diversity of clinical cases to investigate. The system allows immediate feedback to the student, and unlike with a live animal, the instructor knows exactly what the student is feeling and where, ''anatomically,'' the student's fingers are in contact.

As costs for VR decrease, projects at other colleges will no doubt be initiated in order to enhance veterinary training.

4. Ethically Sourced Animal Cadavers and Tissue

The study of anatomy in veterinary medicine would not be complete without hands-on work with animal cadavers and tissue. These resources are also excellent tools for clinical skills training and for the practice of surgical techniques, once basic competency has been gained using non-animal alternatives. Ethical alternatives to the use of killed animals for such cadaver requirements do exist—specifically, the use of ethically sourced animal cadavers and tissue. The term ''ethically sourced'' refers only to cadavers and tissue obtained from animals that have died naturally or that have been euthanized in response to natural terminal disease or non-recoverable injury.[2] Animals that have been harmed or killed to provide cadavers and tissue are not considered ethically sourced, nor are those sourced from places where harming or killing is commonplace. Furthermore, for the acquisition to be considered ethical, no market should be created or supported.

The use of ethically sourced cadavers is standard practice in human medicine. Most medical schools have well-established body-donation programs, whereby, in their wills, individuals can donate their bodies for use by a specific medical school for student gross anatomy laboratories and dissections. The ethical sourcing of animal cadavers is potentially easier to implement than for human cadavers although in the former case the animal guardian is an essential intermediary. The most practical sources of animal cadavers are veterinary teaching hospitals and independent veterinary clinics, typically through body-donation programs. In these programs, clients of a clinic consent to donating the cadaver of their companion animal after the animal's natural death or euthanasia. Body-donation programs provide an excellent example of the multi-benefit solutions that the process of implementing alternatives can offer. Kumar[14] reports that students appear to have a better appreciation of anatomy and exhibit more mature behavior in taking care of cadavers with animals provided by a client donation program and that such a program is cost effective. According to Kumar, ''The cadaver needs of the first year gross anatomy course, as well as those of our clinical skills and medical procedure laboratories, are fully met. No healthy animal is sacrificed for the purpose of teaching.''[14] With increased cooperation between the departments of pathology, anatomy, and surgery, other possible sources of cadavers would include university pathology departments.

An important issue that needs to be addressed is that of the preservation and storage of cadavers. Cold storage within anatomy or pathology labs will keep cadavers in good condition and minimize autolysis, but re-use of cadavers and storage for future use require more than continuous storage in a cool room. Freezing cadavers is one solution, and careful preparation before freezing can help with the successful preservation of tissue and help ensure even thawing before use. Embalming fluids are also very often used to fix cadavers, as is the standard procedure with donated-human-body programs. Freeze-drying, silicone impregnation (silyophilisation), and a range of plastination techniques are increasingly being used for the preservation of cadavers, organs, and thin slices.

REVIEWS, ASSESSMENT, AND STUDENT LEARNING PERFORMANCE WITH HUMANE EDUCATIONAL APPROACHES

Conventional animal experimentation has not been subject to the same scrutiny and demand for assessment as have modern teaching aids and approaches. Many teachers seem to continue animal practicals on the basis of tradition. When it comes to alternatives and humane education, however, the question of student performance is often central. A number of studies have been conducted to assess differences in learning performance as between conventional animal practicals and various alternative tools and approaches.[15]

However, a simple comparison between the animal practical and the alternative is not always sufficient to fully investigate the potential and impact of alternatives. All curricular design involves combining tools from many different sources, and alternatives will almost always be used in combination to meet teaching objectives and to achieve a comprehensive learning experience. Nerve-muscle physiology practicals may combine computer simulation with student self-experimentation, and surgery courses may offer a range of different simulators in conjunction with clinical apprenticeship. To assess the learning experiences fully, it is often more appropriate to compare the use of a combination of tools with the animal practical, rather than the use of one tool in isolation. Moreover, a fully humane education will often involve careful design to meet additional important teaching objectives, like post-operative care in clinical courses or the problem-solving abilities encouraged through computer simulation.

A range of reports has suggested that the techniques described in this paper provide for good education and, as reported by Balcombe,[15] over 30 studies have been published that suggest the alternatives to be equal or superior in terms of teaching efficacy when compared to conventional animal practicals. Many of the proposed ''alternative'' techniques are not seen as ''alternative'' but are at the forefront of approaches that are being developed to improve training in the health sciences and in other areas of education. Most of these can be expected to become part of the mainstream of any good education program, in veterinary medicine and other health and life sciences. Below, we review briefly some of the evaluations of these methods, either as alternatives to the harmful use of animals or simply as good approaches to teaching.

Computer-aided instruction is gaining a strong foothold as an educational tool.[8] For example, Erickson and Clegg[16] found that veterinary students rated computer-based active learning the best of several different methods for learning the basic cardiac curriculum and the interpretation of electrocardiographs. Block et al.[17] reported that medical students found simulator models ''to be superior to the animal model in teaching surgical airways and for management of pneumothorax.'' Similarly, computer-based teaching aids typically performed equally well or better in physiology or pharmacology courses taken by medical students,[18] veterinary students,[19] nursing students,[20] pharmacology majors,[21] and physiology undergraduates.[22,23] Dewhurst and Meehan[22] have pointed out that the cost of the animal practical was five times greater than that of the computer simulation, and Fawver and colleagues[19] found that the alternatives ''saved faculty time.'' A study by Samsel and colleagues[18] found that the computer-based session for cardiovascular physiology teaching received a higher rating from students than did comparable animal demonstrations.

Regarding the acquisition of basic competency in clinical skills and surgery, a range of models has been assessed. Olsen and colleagues[24] reported that a hemostasis model was as effective as live animals for teaching veterinary students the basic skills involved in blood-vessel ligation. Soft-tissue models of canine abdominal organs developed at the University of Illinois were found to have handling properties comparable to those of actual organs and were useful for teaching a range of common surgical procedures.[25] The DASIE (Dog Abdominal Surrogate for Instructional Exercises), developed at the Ontario Veterinary College has also been a useful tool for teaching abdominal surgery at a number of institutes.[26,27] In the case of human medicine, clinical procedures like endoscopy, often practiced using live animals as surrogate patients, can be taught using VR simulations. Simulations significantly improved practitioner performance,[28,29] and were superior to conventional training methods in the acquisition of procedural skills.[30] Even the simplest of alternatives has been shown to meet the teaching objectives of basic skills acquisition: Packer and colleagues[31] reported that a videotaped demonstration could compete with a live-animal demonstration, with either teaching method allowing students to develop a similar level of understanding of the principles behind the exercise.

Carpenter and colleagues[32] reported no significant difference in the surgery performance of two groups of veterinary students, half trained using live animals and the other using cadaver surgery. Modern models can even offer a better education, as reported by Griffon and colleagues,[33] who drew the conclusion that the model used in their study was more effective than cadavers in teaching basic surgical skills and ovariohysterectomy in dogs. In another study, a comparison of the acquisition of surgical skills in veterinary students was undertaken, with students being randomly assigned to two groups—one where they learned with soft-tissue plastic models, the other with anaesthetized dogs who were euthanized at the end of the practical.[34] The students' surgical competence was then assessed during a spay surgery on a dog or cat from an animal shelter. Faculty members supervised these sessions and determined whether the students' cognitive and motor skills were sufficient. These spay surgeries were also videotaped, arranged in random order, and evaluated by eight surgeons from four veterinary schools. Students were re-evaluated a year later. The study showed no significant differences in the grades for the two groups. The researchers noted that this ''makes a strong point that the students in the model training group were trained in surgery as well as or better than the students in the traditional training group.''[34] They concluded by saying, ''We believe that the models would have been an even more effective teaching tool if they had been available to students at times other than the laboratory sessions, and if the procedures performed on the models were the same procedures subsequently performed on the live animals.''

Another study of veterinary students who took an alternative small-animal surgical procedure course at Tufts University[15] had their employers rate the students in surgical competency when they were hired and a year afterwards. No significant differences were found for any of the measures. This study is important because it assessed the learning experience by addressing the performance of procedures during employment. Assessment of alternatives by practitioners has also been conducted.[25] Models of the canine spleen, kidney, and liver were made from soft plastic to simulate the organs of the live animal as closely as possible in appearance and tissue handling properties. Each organ model was independently evaluated by five small-animal surgeons who performed several common surgical procedures on each model. It was concluded that all models had a realistic appearance and were useful for teaching each of the procedures evaluated.[25]

CLINICAL PRACTICE

The end goal of veterinary education is to provide new graduates with the clinical skills necessary to provide animals with optimum care. This clearly involves direct, hands-on care, including a range of invasive approaches to diagnosis and treatment. A primary issue is how to help newly admitted veterinary students, most often with few or no clinical skills, make the transition (often a multi-year process) and become professionals, competent in a breadth of procedures, *without* the well-being of animals being compromised.

In all primary veterinary schools and colleges, the training of veterinary students involves direct experience with real patients and is undertaken as part of the provision of clinical care by faculty clinicians and private practitioners. This type of care is mostly directed to treating sick animals brought to the facilities by clients/animal guardians and providing for the animal's wellness by prophylactic treatments such as immunization. However, in some colleges and some countries around the world, students still typically use laboratory animals for clinical-skills and surgery training and do not have access to the learning opportunities associated with clinical work on patients. Such use of laboratory animals needs to be replaced by humane programs of education—for example, with the student as part of the care giving team.

For the veterinary student, work with living animals is essential, but the animals themselves should always benefit from the experience, or at least not be harmed. Veterinary teaching hospitals and independent veterinary clinics have a constant flow of patients that can contribute to effective and rewarding student education by allowing a stepwise development from the observation of procedures, through student-assisted activities, to the performance of basic procedures by students. Essential professional abilities can be gained in this way, through experiencing and dealing with the clinical environment and its demands. It is essential that students learn how to work with animal patients, something likely best achieved through clinical work in clinical, problem-solving environments. Veterinary students can gain key clinical-skills and surgical experience very effectively, and simultaneously, the animals benefit. Students can also gain an appreciation of the diversity of patients and clinical situations and improve skills in communicating with colleagues and animal guardians.

To achieve this and to meet humane standards, several factors are paramount. First, the animal should not be harmed by the lack of experience of the novice student clinician, and it is, therefore, essential that the supervising clinician ensure that all experiences with and use of animals be either neutral or beneficial in their effect on the animals.[35] Neutral work with animals, involving routine maintenance, can provide key skills in animal handling.

Involvement by students in clinical work with animals requires that they have the appropriate level of skills mastery. Students should be encouraged early to participate in non-harmful clinical-skills training. As described in detail in prior sections of this paper, non-animal alternatives—such as models, mannequins, and simulators—can be powerful tools with which students can learn and acquire many clinical skills. Computer simulation can provide experience in anesthesia management, critical care, and various procedures. In accordance with Smeak, ''[A]fter basic skills are mastered, cadavers from ethical sources are excellent aids for teaching tissue layers and exposure, surgical anatomy and basic closure methods. Finally students can then 'graduate' to treating live animals who are simultaneously patients receiving beneficial treatment.''[36]

The use in some veterinary colleges of ''clinic'' animals, kept and used repeatedly for training procedures, and the use of animals for experiments and terminal surgeries, work against the veterinary ethic of animal care and healing. As described within this paper, there are now a range of approaches that can be used to provide for the transition from new student to one with clinical competence, without the well-being of animals being compromised. It is to be expected that more and more such alternatives, with ever-increasing sophistication, will rapidly become available. In Smeak's opinion,[36] students can be better prepared for clinical surgery by using alternative teaching techniques. It is surely the obligation of veterinary faculties to adopt such approaches within their curricula.

CONCLUSION

Veterinary education deserves further investment to provide all students with the most ethical and effective methods for the acquisition of knowledge and skills. Such an investment in alternatives will benefit all the groups concerned—not only the students, the teachers, and the animals, but also the veterinary profession and society in general. Innovation in the field of education is providing an ever-increasing number of high-quality software products, mannequins, simulators, and other alternatives to the harmful use of animals as teaching aids. Hopefully, a new generation of veterinary students is graduating, having experienced the best-practice teaching made possible by this creativity and curricular transformation. They will be a generation of veterinarians who have not, during their education, gone against the creed of ''first, do no harm.''

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